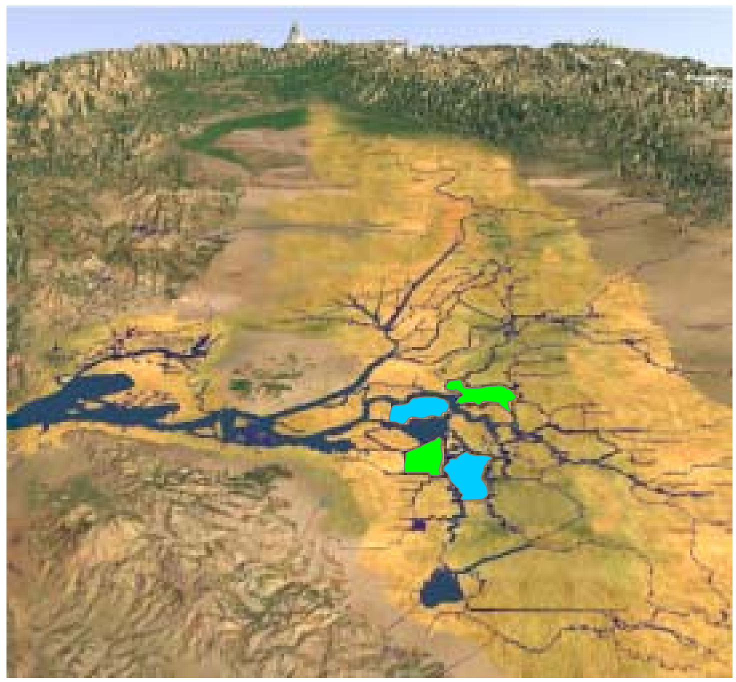
INTEGRATED STORAGE INVESTIGATIONS

CALIFORNIA BAY-DELTA AUTHORITY

IN-DELTA STORAGE PROGRAM
STATE FEASIBILITY STUDY
DRAFT REPORT ON OPERATIONS



Division of Planning and Local Assistance
Department of Water Resources
July 2003

ORGANIZATION

FOREORD

We acknowledge the technical assistance provided by Reclamation in carrying out the role of federal lead agency for the CALFED Integrated Storage Investigations. Reclamation has not yet completed a full review of the State Feasibility Study reports. Reclamation will continue to provide technical assistance through the review of the State Feasibility Study reports and DWR will work with Reclamation to incorporate comments and recommendations in the final reports.

State of California
Gray Davis, Governor

The Resources Agency
Mary D. Nichols, Secretary for Resources

California Bay-Delta Authority	**Department of Water Resources**	
Patrick Wright, Director	Michael J. Spear, Interim Director	Stephen Verigin, Acting Chief Deputy Director
Wendy Halverson-Martin, Chief Deputy Director	Jonas Minton, Deputy Director	Tom Glover, Deputy Director
	Lucinda Chipponeri, Deputy Director	Peggy Bernardy, Chief Counsel
	Mark Cowin, Chief, Division of Planning and Local Assistance	

This report was prepared under the direction of

Division of Planning and Local Assistance
Stephen S. Roberts, Chief
Surface Storage Investigations Branch
Tirath Pal Sandhu, Project Manager
In-Delta Storage Program

With Major Contributions from

Operations Studies Team
Jeremy Arrich, Senior Engineer, WR
Ganesh Pandey, Engineer WR
Amarjot Bindra, Engineer WR
Sushil K. Arora, Supervising Engineer WR
Dan Easton Engineer WR
Ryan Wilbur Engineer WR
Sean Sou, Supervising Engineer WR
Mike Moncrief, Engineer WR

Water Quality Investigations Team
Tara Smith, Supervising Engineer WR
Parviz Nader-Tehrani, Senior Engineer WR
Bob Suits, Senior Engineer WR
Hari Rajbhandari, Senior Engineer WR
Mike Mierzwa, Engineer WR
Ganesh Pandey, Engineer WR
Robert DuVall, Environmental Scientist

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

1.1 General

The purpose of the operation studies was to evaluate the potential benefits of the In-Delta storage reservoirs in terms of ecosystem enhancement of the Bay-Delta estuaries and improvement in the supply and reliability of water supply systems for the State and Central Valley users. Addition of the In-Delta storage reservoirs to the Central Valley Project (CVP) and State Water Project (SWP) systems could have beneficial or adverse impacts to the existing supply systems and Delta ecosystems. Thus, evaluations of potential impacts of the planned reservoirs are important to highlight the rational of the planned project and justifications for its construction costs. As the project is supposed to meet water quality requirements for the urban intakes drinking water quality standards, an acceptable In-delta storage operation is necessary to resolve water quality issues.

This report presents information on operations studies conducted to determine the project yield and meeting all SWRCB D1641 Water quality Control Plan (WQCP), D1643, CUWA Water Quality Management plan (WQMP) and biological opinions. California Simulation Model -II (CALSIM) and the Delta Simulation Model (DSM2) were used to simulate reservoir operations.

1.2 Project Background

The proposed In-Delta Storage Project (Figure 1.1) consists of creating two reservoir islands (Webb tract and Bacon Island) and two habitat islands (Holland Tract and Bouldin Island) all located in the San Joaquin-Sacramento Delta area. The In-Delta storage project envisions the diversion of water onto the reservoirs during the winter season, when there is plenty of water in the Delta. The stored water will be released back to the system during spring and summer time when the demand is high and supply is low.

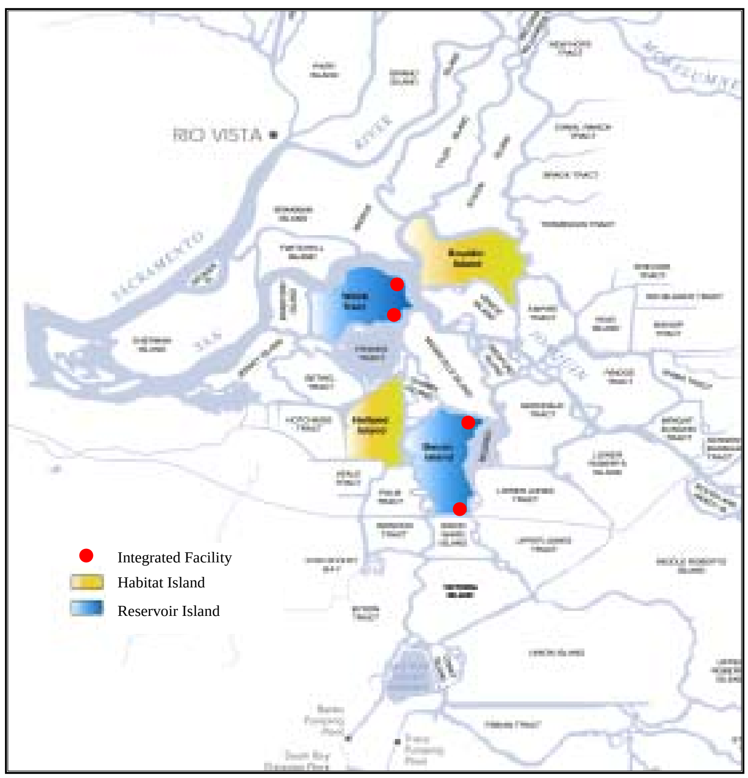


Figure 1.1: In-Delta Storage Project Islands and Integrated Facility Locations

Maximum Diversions and releases from outlet structures are shown in Figures 1.2 and 1.3. The exchange of water to and from the reservoirs will be made through four Integrated Facilities (two structures on each of the storage islands). The combined storage capacity of the reservoirs is 217 TAF. Maximum permitted diversion onto the reservoir islands and habitat islands is 9,000 cubic feet per second (cfs). The maximum allowable release is not mentioned in the permit, however, the integrated facilities design allows a total of 9,000 cfs release from reservoir islands. Some of the main benefits of the In-Delta Storage Project are as followings.

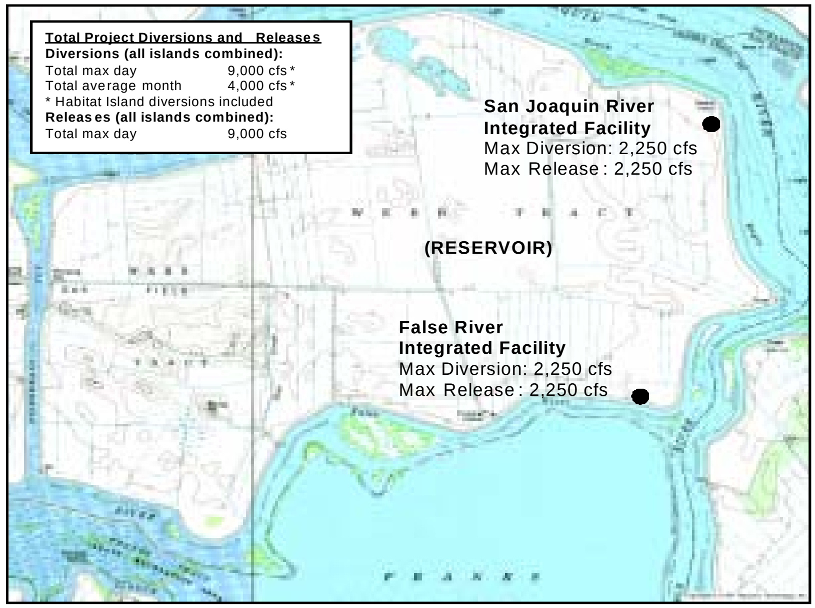


Figure 1.2: Webb Tract Storage and Integrated Facilities

- Provide water to meet Delta Standards and supplement flows released by SWP and CVP to meet such standards. The project is strategically situated to manage Delta conditions and respond over shorter time spans.
- Create additional benefits for environmental purposes (EWA, CVPIA, ERP). It would not create any new water for EWA but would add flexibility to the system for times when EWA can restrict exports and then make up for export reductions by using the stored water in the Delta. The project could improve flow releases and export timing to benefit Delta fisheries and improve water quality for fish in the Delta.
- Increase reliability and flexibility through additional water supply and increase in upstream carryover. The additional water supply should result from capturing surplus flows in the Delta. Also water stored during excess periods when released for Delta requirements, may result in savings for projects and can end up as additional carryover in SWP and CVP reservoirs**.**

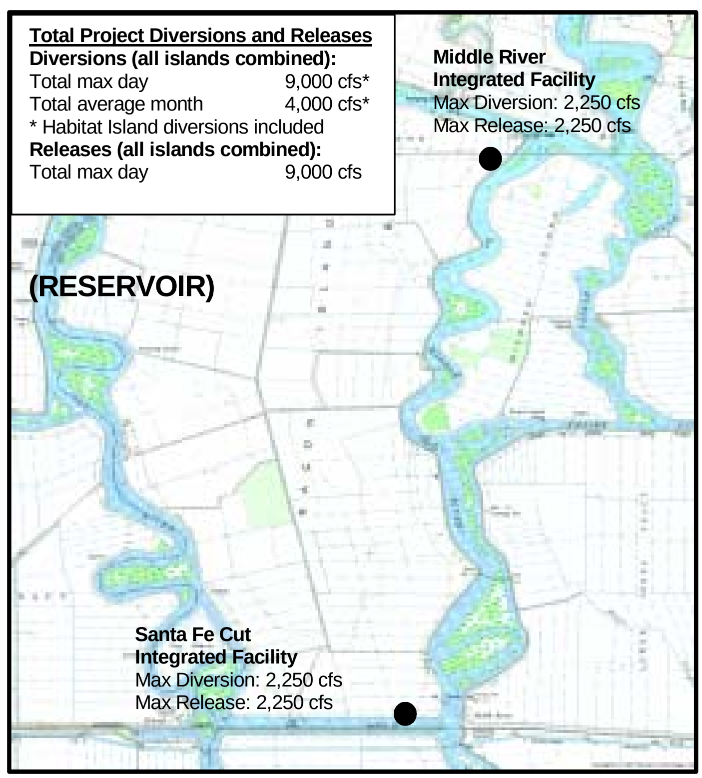


Figure 1.3: Bacon Island Storage and Integrated Facilities

- Releases from storage could reduce salinity intrusion and result in water quality benefits.

- Provide storage and water marketing for sale, exchange, lease or transfer of water from one user to another.

1.3 Operational Concept

In-Delta Storage reservoirs will be operated as a component of the SWP and CVP Systems (Public Ownership). Thus, the operation rules will be based on the water quality constraints set forth by the 1995 WQCP D1641, and other existing flow and water quality standards of the Delta.

Operational studies were conducted with California Simulation Model -II (CALSIM) and the Delta Simulation Model (DSM2). As standards in the Delta are daily standards, daily versions of these models were used. A number of operating scenarios were designed to evaluate the impacts of the planned project into several aspects of the Delta systems. Each scenario differs with other in terms of operation constraints, regulatory standards, and water demand. In general, the operation study covers the period of WY1922 through WY1994, however, for some scenarios the study period will be limited to WY1974 through WY1991. The operation studies assume 2030 level of hydrology and development. Project yields from each scenario is compared and contrasted with the yields from existing system configurations. Additional information on operating criteria and use of models is presented in the following sections.

1.4 Key Findings and Recommendations

Based upon the CALSIM operation studies, the In-Delta storage reservoirs will have the following beneficial impacts in the Delta and system-wide benefits for the SWP and CVP.

- Due to strategic location, the operation of the island reservoirs would contribute to operational flexibility of the SWP and CVP systems. In-Delta storage reservoirs would provide new additional supplies for the SWP and CVP users and create additional carryover storage in upstream CVP and SWP reservoirs.

- Coordinated operation of CVP and SWP would help meet the ecosystem needs of the Delta. Future operations can be refined in consultations with regulatory agencies for improvements in habitat quality and availability for fish and other aquatic organisms inhabiting the Bay-Delta system. The timing of environmental water allocations would be flexible depending on the specific environmental benefit to be achieved (e.g. protection of spring-run chinook salmon and delta smelt).

- Due to the possibility of carryover storage in the upstream SWP and CVP reservoirs as a result of storing water in the Delta, CALFED's ERP and storage programs should work closely with regulatory agencies to maximize the program benefits and assure compliance of the Endangered Species Act.

- EWA benefits could be provided either by dedication of 900 cfs supply to CVP and SWP or by a direct connection to Clifton Court Forebay. A direct connection to CCF using a pipeline would provide “fish free” water, because the water was screened using state-of-the-art fish screens on Bacon Island would support the Conveyance Program’s goal to screen CCF up to 10,300 cfs. Further evaluation of this connection as a part of the conveyance studies is recommended to evaluate possible savings in fish screening structures being proposed for the new CCF Intake.

- Due to strategic location of the In-Delta reservoirs, immediate actions are possible for salinity control. The reservoirs have a favorable impact in the location of X2 line in the Delta.

- DOC water quality problem could be mitigated using circulation operations.

- A coordinated operational study with In-Delta storage and Los Vaqueros Expanded Reservoir indicates both projects can share Delta surplus flows. Further studies should be conducted to maximize benefits.

- Comparative information on three storage programs (Shasta Enlargement, Sites Reservoir and Storage in the San Joaquin Basin), could not be completed in this study. As these projects are at different levels of study, CALSIM II model needs further development.

Chapter 2: Operation Criteria

2.1 Level of Development

For the existing base line conditions, the 2001 level of land use is assumed. The existing SWP and CVP systems are being operated according to the SWRCB's Water Rights Decision 1641. The system yields for the current conditions include criteria imposed by the hydrological, water demands, existing facilities, regulatory D1641 standards and COA operations.

For the State Feasibility Study, evaluations were planned to be completed for a 2030 level of development. However, 2030 hydrology is currently being developed under the Common Assumptions multi-agency task that may be completed during the next year. The present study assumed 2020 level of development for the No Action baseline and Project conditions. To achieve the above objectives, the operational study considers a 2030 level of development to determine new or additional yield that the In-Delta project would generate above the existing conditions. To evaluate the benefits of In-Delta project in the CVP and SWP systems, two operation scenarios based upon the operation rules, hydrology and water demands were considered. The first case considers the project yield for existing systems without the planned project. In the second case, the operation rules, hydrology and demand were redefined to highlight the performance of the In-Delta storage reservoirs in water quality, supply and reliability, and enhancement of Delta ecosystems. The following sections summarize some of the operation rules that must be met in order to operate existing and planned projects in the Sacramento-San Joaquin Delta.

2.1.1 Existing Base Case Condition

The existing system would be operated according to State Water Resources Control Board's (SWRCB's) Water Rights Decision 1641 (D1641). The system yields were determined based upon the criteria imposed by the following constraints.

- Hydrology
- Demands
- Facilities
- Regulatory standards (D1641), and
- Operation Criteria (COA)

2.1.2 No Action Scenario

No action scenario represents yield from the CVP and SWP systems without the planned project for the 2020 level of development and hydrology. Thus, this scenario provides a basis for the comparison of the project performances. A 2020 level no action condition was defined to represent a reasonable range of uncertainty in the pre-implementation condition. Although land use change is expected from the present to the 2020 level planning horizon, hydrological studies indicate that future 2020 level hydrology based water supply may not show appreciable change. With the increase in population, water demands are expected to change. The projected demand for the State Water Project varies between 3.4 MAF and 4.2 MAF and the maximum interruptible demand is 134 TAF/month. The projected annual Central Valley Project demand is 3.5 MAF, which includes the annual Level II Refuge demand of 288 TAF. The Cross Valley Canal demand is 128 TAF/year and the Banks Pumping Plant export capacity of 8,500 cfs was used. Trinity River Minimum Fish flows below Lewiston Dam are maintained at 340taf/year.

For the No Action baseline, Revised Fish (REV FISH) alternative was assumed as the base. The assumptions for baseline existing and future No Action are summarized in Table 2.1.

Table 2.1: Proposed CALSIM Baseline Inputs for Common Assumptions

	Existing Condition[1] (Monthly model)	**Future No-Action Condition[2] (Monthly model)**	**Future No-Action Condition[3] (Daily model)**
Period of Simulation	73 years (1922-1994)	Same	Same
HYDROLOGY			
Level of Development (Land Use)	2001 Level, DWR Bulletin 160-98[4]	2020 Level	2020 Level
Demands **North of Delta (exc American R)**			
CVP (non-settlement)	Land Use based, limited by Full Contract	Same	Same
(Settlement)	Land Use based, historical	Land Use based, historical	Land Use based, historical
SWP (FRSA)	Land Use based, limited by Full Contract	Same	Same
Non-Project	Land Use based	Same (may adjust as a result of conservation)	Same (may adjust as a result of conservation)
CVP Refuges	Firm Level 2[5]	Same (for interim formulation runs – may change by final runs)	Same (for interim formulation runs – may change by final runs)
American River Basin			
Water rights	2001[6]	Alt 2 formulation of AR Contract Renewal EIS	Alt 2 formulation of AR Contract Renewal EIS

[1] This represents the CEQA condition of "existing conditions" as assumed by the Common Assumptions Work Group.

[2] This represents the NEPA condition of "future with no-action" as assumed by the Common Assumptions Work Group.

[3] This represents the NEPA condition of "future with no-action" as assumed for the In-Delta Storage Investigation using the CALSIM Daily model – which functions differently than the CALSIM II monthly time-step model.

[4] 2001 Level of Development defined by linearly interpolated values from the 1995 Level of Development and 2020 Level of Development from DWR Bulletin 160-98

[5] It is assumed that Level 4 supplies are obtained through water transfers and are not part of the basic operating demands in CALSIM.

	Existing Condition[1] (Monthly model)	Future No-Action Condition[2] (Monthly model)	Future No-Action Condition[3] (Daily model)
		(may adjust as a result of conservation)	(may adjust as a result of conservation)
CVP	2001[7]	Alt 2 formulation of AR Contract Renewal EIS (may adjust as a result of conservation)	Alt 2 formulation of AR Contract Renewal EIS (may adjust as a result of conservation)
San Joaquin River Basin			
Friant Unit	Regression of historical	Same	Same
Lower Basin	Fixed annual demands	Same	Same
Stanislaus River Basin	New Melones Interim Operations Plan	Same[8]	Same[9]
South of Delta			
CVP	Full Contract	Same (may adjust as a result of conservation)	Same (may adjust as a result of conservation)
CCWD	140 TAF/YR[10]	195 TAF/YR	195 TAF/YR
SWP (w/ North Bay Aqueduct)	3.0-4.1 MAF/YR	3.3-4.1 MAF/YR (may adjust for conservation, recycle, desal)	3.3-4.1 MAF/YR (may adjust for conservation, recycle, desal)
SWP Interruptible Demand	MWDSC up to 50 TAF/month, Dec-Mar, others up to 84 TAF/month	Need to check in with MWD	Need to check in with MWD
FACILITIES			
System-wide	Existing Facilities (2001)	Same	Same
Upper American River	PCWA pumps[11]	Same	Same
REGULATORY STANDARDS			
Trinity River			
Minimum Flow below	Trinity EIS Preferred		

[6] 1998 Level Demands defined in Sacramento Water Forum's EIR with a few updated entries; assumptions for each purveyor are presented in Appendix B

[7] Same as footnote 6

[8] Because a new operating plan has not been determined, the interim plan is the default plan for future no-action conditions.

[9] Because a new operating plan has not been determined, the interim plan is the default plan for future no-action conditions.

[10] Delta diversions include operations of Los Vaqueros Reservoir operations

[11] The Placer County Water Agency facility is just about to begin construction – pumps in American River upstream of Folsom

	Existing Condition[1] (Monthly model)	Future No-Action Condition[2] (Monthly model)	Future No-Action Condition[3] (Daily model)
Lewiston Dam	Alternative (369-815 TAF/YR)		
Trinity Reservoir End-of-September Minimum Storage	Trinity EIS Preferred Alternative (600 TAF as able)		
Clear Creek			
Minimum Flow below Whiskeytown Dam	Downstream water rights, 1963 USBR Proposal to USFWS and NPS, and USFWS discretionary use of CVPIA 3406(b)(2)	Same	Same
Upper Sacramento River			
Shasta Lake End-of-September Minimum Storage	SWRCB WR 1993 Winter-run Biological Opinion (1900 TAF)		
Minimum Flow below Keswick Dam	Flows for SWRCB WR 90-5 and 1993 Winter-run Biological Opinion temperature control, and USFWS discretionary use of CVPIA 3406(b)(2)		
Feather River			
Minimum Flow below Thermalito Diversion Dam	1983 DWR, DFG Agreement (600 CFS)	Same	Same
Minimum Flow below Thermalito Afterbay outlet	1983 DWR, DFG Agreement (1000 – 1700 CFS)	Same	Same
Yuba River			
Minimum Flow	SWRCB D-1644		
American River			
Minimum Flow below Nimbus Dam	SWRCB D-893 (see accompanying Operations Criteria), and USFWS discretionary use of CVPIA 3406(b)(2)		
Minimum Flow at H Street	SWRCB D-893		

	Existing Condition[1] (Monthly model)	Future No-Action Condition[2] (Monthly model)	Future No-Action Condition[3] (Daily model)
Bridge			
Lower Sacramento River			
Minimum Flow near Rio Vista	SWRCB D-1641	Same	Same
Mokelumne River			
Minimum Flow below Camanche Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (100 – 325 CFS)	Same	Same
Minimum Flow below Woodbridge Diversion Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (25 – 300 CFS)	Same	Same
Stanislaus River			
Minimum Flow below Goodwin Dam	1987 USBR, DFG agreement, and USFWS discretionary use of CVPIA 3406(b)(2)	Same	Same
Minimum Dissolved Oxygen	SWRCB D-1422	Same	Same
Merced River			
Minimum Flow below Crocker-Huffman Diversion Dam	Davis-Grunsky (180 – 220 CFS, Nov – Mar), and Cowell Agreement	Same	Same
Minimum Flow at Shaffer Bridge	FERC 2179 (25 – 100 CFS)	Same	Same
Tuolumne River			
Minimum Flow at Lagrange Bridge	FERC 2299-024, 1995 (Settlement Agreement) (94 – 301 TAF/YR)	Same	Same
San Joaquin River			
Maximum Salinity near Vernalis	SWRCB D-1641	Same	Same
Minimum Flow near	SWRCB D-1641, and	Same[12]	Same

[12] It is assumed that VAMP or a functional equivalent would still be in place in 2030 since such actions are undertaken to meet a regulatory standard specified in D-1641

	Existing Condition[1] (Monthly model)	Future No-Action Condition[2] (Monthly model)	Future No-Action Condition[3] (Daily model)
Vernalis	Vernalis Adaptive Management Program per San Joaquin River Agreement		
<u>Sacramento River-San Joaquin River Delta</u>			
Delta Outflow Index (Flow and Salinity)	SWRCB D-1641	Same	Same
Delta Cross Channel Gate Operation	SWRCB D-1641	Same	Same
Delta Exports	SWRCB D-1641	Same	Same
OPERATIONS CRITERIA			
Subsystem			
<u>Upper Sacramento River</u>			
Flow Objective for Navigation (Wilkins Slough)	Discretionary 3,500 – 5,000 CFS based on Lake Shasta storage condition	Same	Same
<u>American River</u>			
Folsom Dam Flood Control	SAFCA, Operation of Folsom Dam, Variable 400/670 (without outlet modifications)	Same, but *with* outlet modifications	Same, but *with* outlet modifications
Flow below Nimbus Dam	Discretionary operations criteria corresponding to SWRCB D-893 required minimum flow	Same	Same
Sacramento Water Forum Mitigation Water	None	Sacramento Water Forum (up to 47 TAF/YR in dry years) – (the Wedge)	Sacramento Water Forum (up to 47 TAF/YR in dry years) – (the Wedge)
<u>Stanislaus River</u>			
Flow below Goodwin Dam	1997 New Melones Interim Operations Plan	Same	Same
System-wide			
<u>CVP Water Allocation</u>			
CVP Settlement and	100% (75% in Shasta	Same	Same

	Existing Condition[1] (Monthly model)	Future No-Action Condition[2] (Monthly model)	Future No-Action Condition[3] (Daily model)
Exchange	Critical years)		
CVP Refuges	100% (75% in Shasta Critical years)	Same	Same
CVP Agriculture	100% - 0% based on supply	Same	Same
CVP Municipal & Industrial	100% - 50% based on supply	Same	Same
SWP Water Allocation			
North of Delta (FRSA)	Contract specific	Same	Same
South of Delta (including North Bay Aqueduct)	Based on supply; Equal prioritization between Ag and M&I	Same	Same
Delta Pumping			
Subject to continuing discussions	6,680 cfs, can increase up to 8,500 cfs Dec15-Mar15 (min. of 300 cfs)		8,500 cfs
Tracy pumping	4,600 cfs (minimum of 800 cfs)		4.600 cfs
CVP/SWP Coordinated Operations			
Sharing of Responsibility for In-Basin-Use	Coordinated Operations Agreement		Coordinated operations Agreement
Sharing of Surplus Flows	Coordinated Operations Agreement		Coordinated Operations Agreement
Sharing of Restricted Export Capacity	Equal sharing of export capacity under SWRCB D-1641; use of CVPIA 3406(b)(2) only restricts CVP exports; EWA use restricts CVP and/or SWP as directed by CALFED Fisheries Agencies		Equal sharing of export capacity under SWRCB D-1641
CVPIA 3406(b)(2)			
Allocation	800 TAF/YR (600 TAF/YR in Shasta Critical years)		Not included. Planned for inclusion during the Subsequent EIR/EIS Process.

	Existing Condition[1] (Monthly model)	Future No-Action Condition[2] (Monthly model)	Future No-Action Condition[3] (Daily model)
Actions	1995 WQCP (non-discretionary), Fish flow objectives (Oct-Jan), CVP export reduction (Dec-Jan), VAMP (Apr 15- May 16) CVP export restriction, 3000 CFS CVP export limit in May and June (D1485 Striped Bass cont.), Post (May 16-31) VAMP CVP export restriction, Ramping of CVP export (Jun), Pre (Apr 1-15) VAMP CVP export restriction, CVP export reduction (Feb-Mar), Upstream Releases (Feb-Sep)		
Accounting Adjustments	Per February 2002 Interior Decision, no limit on responsibility for non-discretionary D1641 requirements, no Reset with the Storage metric and no Offset with the Release and Export metrics		
<u>CALFED Environmental Water Account</u>			
Actions	Total exports restricted to 4000 CFS, 1 wk/mon, Dec-Mar (wet year: 2 wk/mon), VAMP (Apr 15- May 16) export restriction, Pre (Apr 1-15) and Post (May 16-31) VAMP export restriction, Ramping of export (Jun)		Not included. Planned for inclusion during the Subsequent EIR/EIS Process

	Existing Condition[1] (Monthly model)	Future No-Action Condition[2] (Monthly model)	Future No-Action Condition[3] (Daily model)
Assets	50% of use of JPOD, 50% of any CVPIA 3406(b)(2) releases pumped by SWP, flexing of Delta Export/Inflow Ratio (not explicitly modeled), dedicated 500 CFS increase of Jul – Sep Banks PP capacity, north-of-Delta (0 - 135 TAF/Yr) and south-of-Delta purchases (50 - 185 TAF/Yr), and 200[13] TAF/YR south-of-Delta gw storage capacity		Not included. Planned for inclusion during the Subsequent EIR/EIS Process
Debt restrictions	No carryover of debt past Sep in model now (may need to be modified), asset carryover ok		Not included. Planned for inclusion during the Subsequent EIR/EIS Process

[13] The EWA has contracted for groundwater storage in facilities owned and operated by Kern County Water Agency and Semitropic Water Storage District.

2.2 Project Operations

Delta is a vital link for the state's water supply. Forty-two percent of the state's annual runoff flows through this maze of islands, marshes and sloughs. State and federal water facilities located in the south Delta pump water to supply farms and cities in central and southern California, providing water to about two-thirds of the state's population and provide minimum required delta outflow. The operation criteria in CALSIM are set such that proposed demands are satisfied while meeting the environmental and water quality standards of the Delta. These requirements, though minimum, are assumed to meet 1995 SWRCB's Water Quality Control Plan objectives and allow Delta exports contained by the export/inflow ratio and permitted pumping capacity. The SWRCB's decision 1641 allowed south of Delta use of Tracy and Banks Pumping Plants for joint point diversion to the Central Valley and the State Water Projects.

2.2.1 Water Quality Management Plan D1641 Requirements

The water quality plan D1641 sets the operation rules to meet the flow standards and water quality standards of the Delta. On the flow standard, D1641 specifies the upper limits on exports amounts from export locations, minimum flow requirements at key locations in the Delta, and the operation schedules of the delta cross channel. On the water quality, the D1641 plan specifies minimum water quality standard requirements at export locations, interior of the Delta, and at southern Delta. D1641 also specifies the limits of water quality for agricultural purposes and sets standards for salinity at San Joaquin River and Suisun Marsh. The diversion and water quality criteria set forth by the D1641 are summarized in Figure 2.1. Some of the criteria set forth by D1641 are given below.

- The maximum 3-day running average combined export (which includes Tracy Pumping Plant and Clifton Court Forebay less Byron Bethany pumping) for the period of April 15 through May 15 should be greater of 1,500 cfs or 100% of 3-day average of Vernalis flow. This time period may need adjustments to coincide with fish migration and the maximum export rate and may be varied by CALFED opinion group.

- For the months of March through June, the maximum Export/Inflow ratio should be equal or less than 0.35. For rest of the months it should be less than 0.65. The definition of export and inflow are given in the footnote of Table 2.2.

- From July through January, the minimum Delta outflow should be between 3,000-8,000 cfs. As explained in Table 2.2, this quantity changes depending upon the type of year.

- From February through June, daily average flow amounting from 7,100 cfs to 29,200 cfs should be allowed as the habitat protection outflow.

- Minimum monthly average flow for September through December at Rio Vista should be kept between 3,000 to 4,500 cfs. For this period, the 7-day running average flow shall not be less than 1,000 cfs below the monthly target value.

- Depending upon the type of year, minimum average flow at Vernalis for the period of February through 15 of April should not be less than 710- 3,420 cfs.

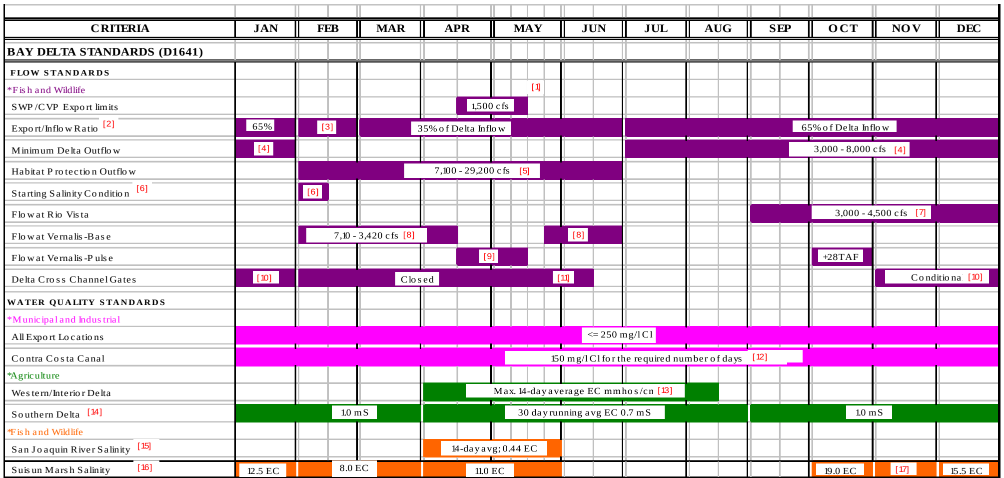
- The delta cross channel should remain closed from November through 15 July.

- At all export locations, the Chlorides (CL) concentration should be less than 250 mg/l for all months of the year.

- The year round mean daily Chlorides (CL) concentration at Contra Costa Canal intake must less than 150 mg/l.

- From the agricultural considerations and for the Western and Interior Delta, the 14 day running average EC between April and 15 of August should be less than 0.45 mS. For the South Delta, April through August 30-day moving average EC should be less than 0.7mS. For the rest of the months, it should be less than 1.0mS.

- The 14-day moving average EC at San Joaquin River salinity between Jersey Point and Pioneers Point for April and May should be below 0.14 mS. The recommended salinity requirements at Suisan Marsh area are summarized in Figure 2.1.



Footnotes

[1] Maximum 3-day running average of combined export rate (cfs) which includes Tracy Pumping Plant and Clifton Court Forebay Inflow less Byron-Bethany pumping.

Year Type	All
Apr 15 - May 15*	The greater of 1,500 or 100% of 3-day avg. Vernalis flow

* This time period may need to be adjusted to coincide with fish migration. Maximum export rate may be varied by CalFed Op's group.

[2] The maximum percentage of average Delta inflow (use 3-day average for balanced conditions with storage withdrawal, otherwise use 14-day average) diverted at Clifton Court Forebay (excluding Byron-Bethany pumping) and Tracy Pumping Plant using a 3-day average. (These percentages may be adjusted upward or downward depending on biological conditions, providing there is no net water cost).

[3] The maximum percent Delta inflow diverted for Feb may vary depending on the January 8RI

Jan 8RI	Feb exp. Limit
<= 1.0 MAF	45%
between 1.0 & 1.5MAF	35% - 45%
> 1.5 MAF	35%

[4] Minimum monthly avg. Delta outflow(cfs). If monthly standard <=5,000 cfs, then the 7-day avg. must be within 1,000 cfs of standard; if monthly standard > 5,000 cfs, then the 7-day avg. must be >= 80% of standard.

Year Type	All	W	AN	BN	D	C
Jan	4,500*					
Jul		8,000	8,000	6,500	5,000	4,000
Aug		4,000	4,000	4,000	3,500	3,000
Sep	3,000					
Oct		4,000	4,000	4,000	4,000	3,000
Nov-Dec		4,500	4,500	4,500	4,500	3,500

* Increase to 6,000 if the Dec 8RI is greater than 800 TAF.

[5] Minimum 3-day running avg. of daily Delta outflow of 7,100 cfs OR:either the daily avg or 14-day running average EC at Collinsville is less than 2.64 mmhos/cm (This standard for March may be relaxed if the Feb 8RI is less than 500 TAF. The standard does not apply in May and June if the May estimate of the SRI is < 8.1MAF at the 90% exceedence level in which case a minimum 14-day running avg flow of 4,000 cfs is required).

[6] February starting salinity: if Jan 8RI>900 TAF, then the daily or 14-day running avg EC @ Collinsville must be <=2.64 mmhos/cm for at least one day between Feb 1-14. If Jan 8RI is between 650 TAF and 900 TAF, then the CalFed Op's group will determine if this requirement must be met.

[7] Rio Vista minimum monthly avg flow rate in cfs (the 7-day running avg shall not be less than 1,000 below the monthly objective).

Year Type	All	W	AN	BN	D	C
Sep	3,000					
Oct		4,000	4,000	4,000	4,000	3,000
Nov-Dec		4,500	4,500	4,500	4,500	3,500

[8] Base Vernalis minimum monthly avg flow rate in cfs (the 7-day running avg shall not be less than 20% below the objective). Take the higher objective if X2 is required to be west of Chipps Island.

Year Type	All	W	AN	BN	D	C
Feb-Apr14 & May16-Jun		2,130 or 3,420	2,130 or 3,420	1,420 or 2,280	1,420 or 2,280	710 or 1,140

[9] Pulse Vernalis minimum monthly average flow rate in cfs. Take the higher objective if X2 is required to be west of Chipps Island.

Year Type	All	W	AN	BN	D	C
Apr15 - May15		7,330 or 8,620	5,730 or 7,020	4,620 or 5,480	4,020 or 4,880	3,110 or 3,540
Oct	1,000*					

*Up to an additional 28 TAF pulse/attraction flow to bring flows up to a monthly average of 2,000 cfs except for a critical year following a critical year. Time period based on real-time monitoring and determined by CalFed Op's group.

[10] For the Nov-Jan period, Delta Cross Channel gates may be closed for up to a total of 45 days.

[11] For May21-Jun15, close Delta Cross Channel gates for a total of 14 days per CALFED Op's group. During the period the Delta Cross channel gates may close 4 consecutive days each week, excluding weekends.

[12] Minimum # of days that the mean daily chlorides <= 150mg/l must be provided in intervals of not less than 2 weeks duration. Standard applies at Contra Costa Canal Intake or Antioch Water Works intake.

Year Type	W	AN	BN	D	C
# Days	240	190	175	165	155

[13] The maximum 14-day running average of mean daily EC (mmhos/cm) depends on water year type.

Year Type	WESTERN DELTA				INTERIOR DELTA			
	Sac River @ Emmaton		SJR @ Jersey Point		Mokelumne R@Terminous		SJR @ San Andreas	
	0.45 EC from April 1 to date shown	EC value from date shown to Aug 15*	0.45 EC from April 1to date shown	EC value from date shown to Aug 15*	0.45 EC from April 1 to date shown	EC value from date shown to Aug 15*	0.45 EC from April 1 to date shown	EC value from date shown to Aug 15*
W	Aug 15		Aug 15		Aug 15		Aug 15	
AN	Jul 01	0.63	Aug 15		Aug 15		Aug 15	
BN	Jun 20	1.14	Jun 20	0.74	Aug 15		Aug 15	
D	Jun 15	1.67	Jun 15	1.35	Aug 15		Jun 25	0.58
C		2.78		2.20		0.54		0.87

*When no date is shown, EC limit continues from April 1

[14] As per D-1641, for San Joaquin River at Vernalis, however, the April through August maximum 30-day running avg EC for San Joaquin River at Brandt Bridge, Old River near Middle River, and Old River at Tracy Road Bridge shall be 1.0 EC until April 1, 2005 when the value will be 0.7 EC.

[15] Compliance will be determined between Jersey Point & Prisoners Point. Does not apply in critical years or in May when the May 90% forecast of SRI<=8.1MAF.

[16] During deficiency period, the maximum monthly average mhtEC at Western Suisun Marsh stations as per SMPA is:

Month	mhtEC
Oct	19.00
Nov	16.50
Dec-Mar	15.60
Apr	14.00
May	12.50

Figure 2.1: Water Quality Management Plan (D1641) Requirements

2.2.2 CVP/SWP Coordinated Operations

Under the Coordinated Operations Agreement (COA), CVP and SWP are required to assure that each project obtains its share of water from the Delta and bears its share of obligations to protect other beneficial uses in the Delta and the Sacramento Valley. Projects share water on agreed upon percentages basis during balanced or excess flow conditions in the Delta. Banks Pumping Plant wheels water for the CVP when there is excess capacity at Banks Pumping Plant. The In-Delta storage project could assist in storing storage withdrawals of CVP water for wheeling by the Banks Pumping Plant into CVP San Luis Reservoir. COA can also help in transferring EWA water. EWA water temporarily stored in In-Delta storage project will be transferred by Banks Pumping Plant to the EWA storage account in San Luis Reservoir. In all, the coordinated operation of CVP and SWP facilities would significantly increase the use of stored water.

2.2.3 Joint Point of Diversions

Coordinated CVP/SWP operations could include a “joint point of diversion and use” to allow water pumped by either project to be used by both users. Before facilities are shared under Joint Points of Diversion agreement, the project sharing its facilities must first meet its own project obligations.

2.3.4 Central Valley Project Improvement Act (CVPIA)

For In-Delta Storage Project, the following objectives of the CVPIA are to be met through reductions in exports and diversions during the months of April and May. No diversions are allowed in April and May. This also meets the Vernalis Adaptive Management Plan (VAMP) requirements. The In-Delta Storage Project can assist in meeting the following CVPIA objectives:

- To protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California
- To address impacts of the Central Valley Project on fish, wildlife and associated habitats
- To improve the operational flexibility of the Central Valley Project
- To increase water-related benefits provided by the Central Valley Project to the State of California through expanded use of voluntary water transfers and improved water conservation
- To contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary
- To achieve a reasonable balance among competing demands for use of Central Valley Project water, including the requirements of fish and wildlife, agricultural, municipal and industrial and power contractors.

To achieve the above objectives, the CVPIA dictates a number of measures to improve the operational flexibility of CVP through expanded use of voluntary water transfers and improved water conservation. Specifically, section 3406 (b)(2) of CVPIA dictates annually 800 taf (600 taf in Shasta critical year) of CVP yield for the primary purpose of implementing the fish, wildlife, and habitat restoration of the Delta. Of this amount, up to 450 taf is to be used to implement the WQCP Delta requirements.

The water allocated to 3406(b)(2) is equivalent to a new water demand on the CVP system and the In-Delta storage project could help to meet this demand. In dry years, water would be released from project facilities or pumping curtailed to meet this water demand. In wet years, when ample water is flowing through the Delta, similar actions would be required to meet the (b)(2) demands. Because this demand is present in all year types and is not reduced by hydrologic factors that may reduce agricultural demands, the net effect of this demand will increase the In-Delta storage project's yield.

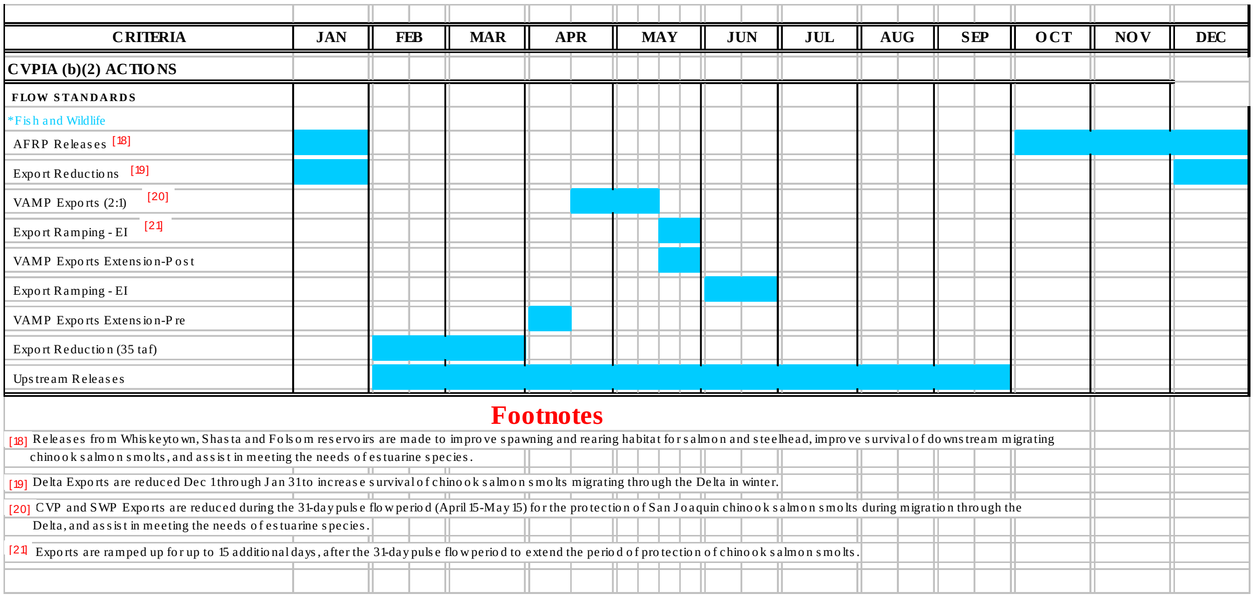


Figure 2.2: CVPIA (b)(2) Actions

2.2.5 Environmental Water Account

The Environmental Water Account (EWA) is a critical component of the CALFED ROD and is managed by USFWS, NMFS and CDFG. The EWA is designed to resolve the conflict between the seasonal needs of the fishery in the Bay-Delta Estuary and the export of water from north to the south. Specifically, the EWA is intended to provide greater flexibility in the operation of export facilities to improve fish protection and recovery while not degrading the reliability and quality of water exported to the south of the Delta. The EWA is authorized to "re-operate" the CVP and the SWP so long as the changes in operations incur no uncompensated costs to the Projects' water users. Under EWA, the agencies acquire and use the EWA water to replace water supply to districts and agencies who loss their supply during the reduced CVP and SWP pumping. The EWA is also used to increase instream flows to protect listed fish species. The EWA is authorized to acquire water (assets) through market transactions with willing sellers (fixed assets) and acquiring water during high flow periods (variable assets). These assets are then used to augment instream flows and Delta outflows, to modify water exports to protect fisheries, and to replace project water that was used to protect fish. The EWA operations criteria are summarized in Figure 2.3.

The EWA largely relies on water transfers from Northern California to fund the account during initial years. Due to limited upstream opportunities in the Sacramento Valley for CALFED Agencies to purchase or otherwise develop water assets, In-Delta storage can provide space for EWA water. The In-Delta project will help add flexibility to the water system to ensure that fish are protected from project operations while allowing for greater water supply reliability for agricultural and urban users.

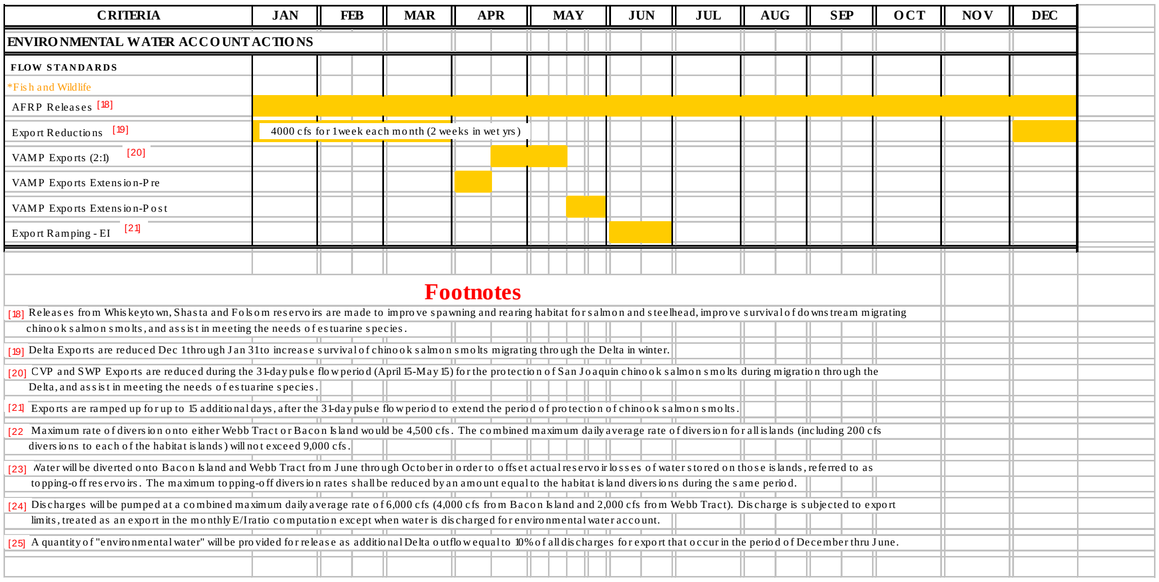


Figure 2.3: EWA Criteria

2.2.6 SWRCB Decision 1643 Requirements

The SWRCB decision 1643 conditionally approves the water right application and petition needed to appropriate water by direct diversion and storage on Webb Tract and Bacon Island as Delta Wetlands Properties. Some of the conditions that the Delta Wetlands Properties must satisfy in order to divert the water into In-Delta storage reservoirs are summarized in Table 2.5. These criteria are in addition to any existing state and federal regulations and standards. The 1643 decision operation criteria can be classified into diversion and release criteria. The operation criteria of the In-Delta Storage project, which is considered as a joint Federal and State project, would be different than the conditions dictated by the SWRCB decision 1643.

2.2.6.1 Diversion Criteria

- Diversion to storage could only occur when Delta is in excess conditions and surplus flows are available.

- Initial diversions to DW Project shall not be made for the current water year (commencing October 1) until X2 has been west of Chipps Island (75 km upstream of the Golden Gate Bridge) for a period of ten (10) consecutive days. After initial X2 condition is met, diversions shall be limited to a combined maximum rate of 5,500 cfs for five (5) consecutive days.

- Maximum rate of diversion onto either Webb Tract or Bacon Island would be 4,500 cfs (9taf/day). The combined maximum daily average rate of diversion for all islands (including diversions to habitat islands) will not exceed 9,000 cfs.

- The maximum annual amount diverted to Webb Tract storage shall not exceed 155 taf per year from January 1 to March 31 and June 1 to December 31 and shall not exceed 106,900 af per year from December 15 to March 31. The total amount of water taken from all sources shall not exceed 417 taf per water year of October 1 to September 30.

- The maximum annual amount diverted to Bacon Island storage shall not exceed 147 taf per year from January 1 to March 31 and June 1 to December 31 and shall not exceed 110,570 AF from December 15 to March 31. The total amount of water taken from all sources shall not exceed 405 taf per water year of October 1 to September 30.

- Diversions shall not exceed 1000 cfs when the 14-day running average of X2 is farther than 80 km upstream of the Golden Gate Bridge, nor exceed 500 cfs if the 14-day running average of X2 is farther than 81 km upstream of the Golden Gate Bridge.

- No Diversions to storage will be made if the Delta is in excess conditions and such diversions cause the location of the 14-day running average of X2 to shift upstream (east) such that X2 is:
  - East of Chipps Island (75 river kilometers upstream of the Golden Gate Bridge) during the months of February through May, or
  - East of Collinsville (81 kilometers upstream of the Golden Gate Bridge) during the months of January, June, July, and August, or
  - During December, east of Collinsville and delta smelt are present at Contra Costa Water District's point of diversion under Water Right Permits 20749 and 20750.

- In the period from September through March DW shall not divert water to storage when X2 is located upstream of Collinsville salinity gauge.

- In the period from October through March, DW Project shall not divert water to storage if the effect of DW Project diversions would cause an upstream shift in the X2 position in excess of 2.5 km (i.e., increase the X2 by 2.5 km).

- In the period from April through May, DW Project shall not divert water to storage.

- If the delta smelt FMWT index is less than 239 (FMWT<239), DW shall not divert water for storage from February 15 through June 30.

- DW Project diversions to storage shall not exceed the following percentage of the available surplus water if FMWT Index > 239:

Month	OCT- JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG- SEP
Diversion (%)	90	75	50	0	0	50	75	90

- If FMWT < 239, DW Project diversions to storage shall not exceed the following percentage of the available surplus water:

Month	OCT-JAN	FEB(1-14)	FEB(15-28)-JUNE	JUL	AUG-SEP
Diversion (%)	90	75	NA	75	90

- DW Project diversions to storage shall not exceed a percentage of the previous day's net Delta outflow rate (assume FMWT Index > 239 scenario):

Month	OCT-DEC	JAN-MAR	APR	MAY	JUN-SEP
Diversion (%)	25	15	0	0	25

- If FMWT<239, DW Project diversions to storage shall not exceed a percentage of the previous day's net Delta outflow rate:

Month	OCT- DEC	JAN-FEB(14)	FEB(15-28) -JUN	JUL-SEP
Diversion (%)	25	15	NA	25

- In the period from December through March, DW Project Diversions to storage shall not exceed the percentage of the previous days San Joaquin River inflow rate.

- If FMWT Index > 239, this limit applies for 15 days during the December through March period whenever DW Project diverts water to storage.

Month	DEC	JAN	FEB	MAR
Diversion (%)	125	125	125	50

- If FMWT Index < 239, this limit applies for 30 days during the December through March period whenever DW Project diverts water to storage.

Month	DEC	JAN	FEB(1-14)	FEB(15-28)	MAR
Diversion (%)	125%	100%	50%	NA	NA

- For the month of March diversion to DW Project shall be reduced to 550 cfs in unless QWEST remains positive.

- Reduce diversion rate to 50% of the previous day's diversion rate during the presence of delta smelt.

- In the period from November through January, when the Delta Cross Channel gates are closed, DW Project shall limit diversions to storage as follows:

Delta Inflow	Maximum Combined Diversion Rate

<=30,000 cfs	3,000 cfs
<=50,000 cfs & >30,000 cfs	4,000 cfs

- Water will be diverted onto Bacon Island and Webb Tract from June through October in order to offset actual reservoir losses of water stored on those islands, referred to as "topping-off" reservoirs. Topping-off diversions shall not exceed the following maximum diversion rate (cfs) and maximum monthly quantity (taf) listed below:

Month	JUN	JUL	AUG	SEP	OCT
Maximum diversion rate (cfs)	215	270	200	100	33
Maximum monthly quantity (taf)	13	16	12	6	2

  The maximum topping-off diversion rates shown above shall be further limited by diversions onto the habitat islands. The maximum topping-off diversion rate and quantity shall be reduced by an amount equal to the habitat island diversions during the same period.

- From September through May, the reservoir islands may be flooded to shallow depths (1ft) to create 200 acres of shallow water rearing and spawning habitat, typically 60 days after reservoir drawdown. After shallow water flooding, water will be circulated till deep water flooding occurs in April or May.

- The maximum rate of proposed diversion onto Holland Tract and Bouldin Island will be 200 cfs per island. Diversions onto the habitat islands will not cause the combined daily average maximum diversion rate of 9,000 cfs for all four project islands to be exceeded. Water will be applied in each month of the year

2.2.6.2 Discharge Criteria

- A combined gravity and pumping maximum daily average rate of 9,000 cfs is used. Combined monthly average reservoir island discharge will be up to 4,000 cfs. Maximum annual release of stored water would be 822 taf.

- Maximum Annual export of stored water would be 250 taf.

- No discharges shall be made for export from Webb Tract from January through June.

- In the period from April through June, DW shall limit discharges for export from Bacon Island to 50 % of the San Joaquin inflow measured at Vernalis.

- DW shall not discharge for export any water from the habitat islands.

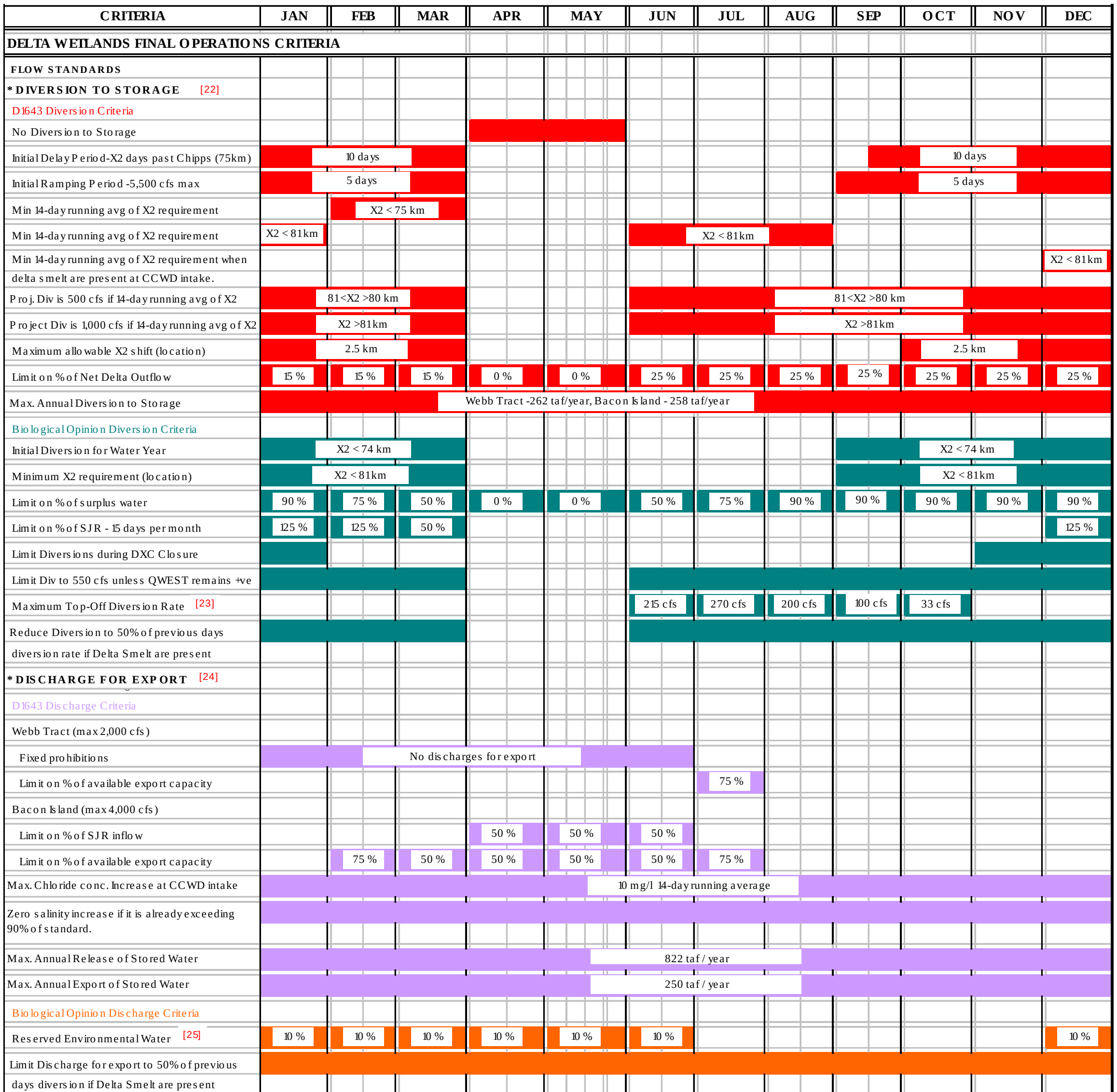
- Reduce the discharge for export rate to 50% of previous day's diversion rate during the presence of delta smelt.

- DW Project discharge is subject to export limits, treated as an export in the monthly E/I ratio computation except when water is discharged for environmental water account and Delta needs.

- In the period from February through July, DW discharges for export shall be limited to the following percentage of the available unused export capacity at the CVP and SWP facilities:

Month	FEB	MAR	APR	MAY	JUN	JUL
Discharge (Bacon Island	75%	50%	50%	50%	50%	75%
Discharge (Webb Tract)	NA	NA	NA	NA	NA	75%

- DW shall reduce the discharge for export rate to 50% of the previous day's diversion rate during the presence of delta smelt.



Footnotes

[22 Maximum rate of diversion onto either Webb Tract or Bacon Island would be 4,500 cfs. The combined maximum daily average rate of diversion for all islands (including 200 cfs diversions to each of the habitat islands) will not exceed 9,000 cfs.

[23] Water will be diverted onto Bacon Island and Webb Tract from June through October in order to offset actual reservoir losses of water stored on those islands, referred to as topping-off reservoirs. The maximum topping-off diversion rates shall be reduced by an amount equal to the habitat island diversions during the same period.

[24] Discharges will be pumped at a combined maximum daily average rate of 6,000 cfs (4,000 cfs from Bacon Island and 2,000 cfs from Webb Tract). Discharge is subjected to export limits, treated as an export in the monthly E/I ratio computation except when water is discharged for environmental water account.

[25] A quantity of "environmental water" will be provided for release as additional Delta outflow equal to 10% of all discharges for export that occur in the period of December thru June.

Figure 2.4: D1643 Constraints in the Delta Wetlands Properties Permit

Chapter 3: Modeling Approach

3.1 CALSIM and DSM2 Planning Models

California Simulation Model-II (CALSIM) is a general-purpose Water Resource Systems Model, developed jointly by US Bureau of Reclamation and California Department of Water Resources. CALSIM simulates the operation of the Federal Central Valley Project (CVP) and the California's State Water Project (SWP) System of reservoirs and conveyance facilities for user specified level of development, inflow/outflow hydrology, and operating rules. CALSIM simulates the system from WY1922 through WY1994 or any other user specified period. In CALSIM historical records of San Joaquin and Sacramento Valley hydrology are adjusted to represent the Delta inflows under current land use pattern. The Delta Simulation Model-2 (DSM2) is a hydrodynamic and water quality model that simulates the flow patterns, and water quality (salinity and/or other constituents) in the Delta region. Thus the CALSIM and DSM2 models jointly allow the planners to examine the flow, stage and water quality conditions of the Delta with and without the planned project.

3.2 Monthly CALSIM Model

CALSIM simulates project operations for a given level-of-development over a 73-year time period using a monthly time step. The level of development (land use) is held constant over the period of simulation. The inflow hydrology is based on the historic period WY1922 to WY1994 but modified to reflect the influence of changes in land use, upstream diversion, and flow regulations. A SWP and CVP, and south of Delta delivery logic uses runoff forecast information and uncertainty. Similarly, delivery versus carryover risk curve and standardized rules (Water Supply Index versus Demand Index Curve) are used to estimate the total water available for delivery and carryover storage. The logic updates delivery levels on monthly scales, from January 1 through May 1, as water supply parameters become more certain.

To estimate the DSM2 model generated salinity at key locations in the Delta, an algorithm that trains its parameter using Artificial Neural Network (ANN) routine, has been used. The ANN flow-salinity module predicts electrical conductivity at Old River at Rock Slough, San Joaquin River at Jersey Point, and Sacramento River at Emmaton. Salinity is estimated based upon time history the Sacramento River inflow, San Joaquin River inflow, DCC gate position, and several Delta export and diversion variables. The Sacramento River inflow term combines the flows from Sacramento River at Freeport, Yolo Bypass, Mokelumne, Consumnes, and Calaveras Rivers. DCC gate position is assumed to be fully open or closed. Delta exports and diversions include SWP exports at Banks Pumping Plant and North Bay Aqueduct, CVP exports at Tracy, Contra Costa Water District diversions, and net channel depletions. A total of 148 days of values of each of these parameters are included in the correlation, representing an estimate of the length of water quality "memory" in the Delta. In CALSIM modeling study, the modeled conditions in a particular year will not conform to the historic observed conditions for the same year. The purpose of CALSIM model is not to recreate historic conditions but to predict potential conditions under various system, regulatory and water demand scenarios.

3.2.1 Limitations of Monthly CALSIM Model

In the monthly CALSIM model many large areas are aggregated to simplify the model operation. This aggregation is generally considered satisfactory for large projects. However, when evaluating the yields from smaller projects, increases in the level of detail of hydrologic inputs may be required. Aggregation in time and space, omits several details of the projects, such as the quick response provided by the In-Delta storage facilities to the operations of the CVP and SWP. Thus, projects benefits could be under/over estimated.

3.3 Daily CALSIM Model Development

The In-Delta storage facilities are located close from the CVP, SWP and other key locations and hence have a quick response time to the systems, from both export and EWA considerations. To account for this response, the In-Delta storage facilities operations (diversions and release rules) required a model that runs on a daily time-step. Thus, a daily time-step Delta Model was created for conducting In-Delta storage project studies. This model was used in conjunction with the CALSIM monthly model. The entire system's operation was simulated for one month period with the CALSIM monthly model and then the information on inflows to the Delta and the south-of-Delta delivery amounts were passed on to the Daily Delta Model. The Daily Delta Model was used to re-simulate the operations in the Delta and the export facilities.

The monthly CALSIM model gives the monthly flows to the delta locations. However, the daily CALSIM model needs daily flow data as its input. Thus, a disaggregating model, which was trained using historical observations, was used to generate the daily flows from the monthly flows. While the daily inflow hydrograph was patterned after the historically recorded inflow, the total volume of the inflow to the Delta provided by the monthly model was preserved.

The results of the Daily Delta Model were provided to the monthly model as the initial conditions for the following month's simulation. The operation of the upstream reservoirs was re-simulated, and any gains or losses of water were reflected in the Delta outflow and the storage at San Luis Reservoir. The next month's simulation was then started with the modified end-of-month storage in San Luis Reservoir and the state of the Delta as simulated by the Daily Delta Model.

The determination of the allowable exports as a function of the salinity standards at various locations in the Delta was accomplished by providing the daily model with the monthly model's ANN estimation of the cap on total exports imposed by the controlling salinity station. This cap on the total exports would be observed every day in the current month's simulation by the daily model and the project exports would never exceed this maximum allowable rate.

In-Delta storage project yield was maximized by adding the storage in the In-Delta facilities to the SWP portion of the San Luis Reservoir by as much vacant space as was available in the SWP San Luis Reservoir before making a computation of the Water Supply Index (WSI). The remaining portion of the storage in the In-Delta Facilities (after subtraction of the vacant space in SWP San Luis Reservoir) was added directly to the SWP delivery target.

To achieve the most efficient operation of the two water supply storage facilities in the with-project simulation run, the priority of filling was given to Bacon Island. This was done because more extended period of allowable discharge from Bacon Island allowed for potential withdrawal and subsequent filling in the same year more readily, whereas the limited allowable period for discharge from Webb Tract made multiple filling in the same year practically impossible. The priority of filling in Bacon Island was achieved by assigning a higher reward for diverting the available water into the conservation storage of Bacon Island as compared to that of Webb Tract.

3.4 Reiterations with DSM2 Model

CALSIM gives optimal set of operation decisions for a given time period under the given set of constraints. Using the CALSIM run as input a base DSM2 run will be made to test the water quality violations, particularly DOC at key locations in the Delta. The DOC from the DSM2 will be analyzed and with the Particle Tracking model a DOC dispersion mechanism will be developed for island discharges. This new algorithm will be implemented in CALSIM to get a more realistic model to assess the impacts of DOC constraints in the urban intakes. With the new inputs, a CALSIM run will be made and the results will be analyzed by the DSM2. The iterations will continue until the DSM2 model shows violations in the DOC water quality at key export locations.

3.5 Interface with DYRESM Model

The numerical model, DYRESM-WQ (Dynamic Reservoir Model – Water Quality) is one dimensional model that predicts temperature, salinity, and water quality in a reservoir by integrating a process based physical model with a biochemical model. In DYRESM-WQ it is assumed that the water bodies comply with the one-dimensional approximation in that the destabilizing forcing variables (wind, surface cooling, and plunging inflows) do not act over prolonged periods of time. DYRESM can be used for simulation periods extending from weeks to decades, and thus the model provides means of predicting seasonal and inter-annual variation in lakes and reservoirs, as well as sensitivity testing to long term changes in environmental factors or watershed properties. DYRSEM-WQ is capable of handling both surface and submerged inflows.

The DYRSEM-WQ model will be used to study the stratification of the reservoir and to predict the temperature differentials between the reservoir islands and the receiving channels. The model will also be used to determine the changes in channel water temperature for the CALSIM and DSM2 model operation scenarios. Calibration and validation of the DYRSEM were not possible because of the project island reservoir does not exist. Thus, calibration of the model was planned using analogous reservoir system. Wind speed measured in the delta will be used as model input, and sensitivity analyses will be conducted by evaluating the impacts of the lower wind speeds. In the present study, the DYRSEM-WQ model will be run for three representative years.

3.6 Interface with Economic Models

Economic models will be used to evaluate the economic justifications for the proposed In-Delta storage reservoirs. Additionally, a project area economic impact analysis will be made to disclose the potential for both positive and negative impacts to the economy of the local area. While the former analysis is traditionally done using only direct costs and benefits, the latter considers indirect and induced local economic effects—the “ripple” effects.

The delivery information from the CALSIM model and stage and flow information from DSM2 model will be used as input in the economic models. The operation rules could be used to estimate the project costs that include the following items.

- Levee maintenance
- Intake and Outlet structures maintenance including pumping stations, gate units, and fish screens for both, reservoir and habitat islands.
- Pumping energy costs
- Seepage control systems maintenance and monitoring
- Water quality monitoring, and
- Environmental monitoring including wildlife and habitat monitoring.

The model output could be used to calculate the project benefits that include the following.

- Additional SWP/CVP system exports for urban and agricultural uses
- Delta Ecosystem needs including Delta WQCP requirements, fisheries and aquatic habitat needs and water quality flow requirements
- Contribution to meet CVPIA requirements including South of Delta Refuges
- Additional Joint Point Diversion Benefits
- Environmental Water Account
- Banking for Water Transfers and carryover storage.
- Recreational Benefits

Chapter 4: Operation Scenarios

4.1 Introduction

A number of operating scenarios were designed to assess potential benefits including environmental enhancement, supply reliability and water quality improvements provided by the In-Delta storage reservoirs to the CVP and SWP systems. For each alternative operating scenario CALSIM (DSM2 as needed) runs will be made to get the system yields. In total 10 alternatives were designed and the planned scenarios comprise the existing conditions and revised alternatives due to the addition of the In-Delta storage project into the CVP/SWP systems. The planned alternatives emphasized project benefits on CVP and SWP joint operation, water quality, fisheries, EWA, and Climate change scenarios. Some of the scenarios were designed to address the multiple set of objectives. These scenarios will help to analyze the pros and cons of the In-Delta storage reservoirs in term of supply reliability, water quality improvements and environmental enhancements of the delta water resources systems.

4.2 Study 1: Base Case Operation

The No Action Base Case scenario, Study 1, simulates the existing condition of the system as outlined in Section 2.1.1. The base scenario considers a 2020 level of hydrology without the In-Delta storage facilities in the system. Thus, the base case scenario represents a "No Action" scenario in the Delta water resources systems. In base case scenario all of the operating rules specified in the D1641 benchmark study, with changes related to the Revised Fish Alternative are used. In the first modifications, fisheries revised banks permitted capacity (8,500 cfs 01July – 15March; 6,680 cfs 16March – 30June) will be used as the export. The second modification considers a joint point of diversion wheeling for the CVP through the Banks pumping plant. The benefits computed with this scenario corresponds the benefits produced by the existing system. Thus, the yields of all subsequent scenarios, which include the benefits from the In-Delta Storage, would be relative to the benefits from the No Action scenario.

At present, water quality studies can be run only for a period of Water Year (WY) 1975 to WY 1991 with DSM2 for a 16-year study due to daily data availability limitations. However, full historical 73-year evaluations are also required for the period from WY 1922 to WY 1994. Results of the No Action Base Case modeling study for 73-year period are given in Table 4.1 and 16-year period are given in Table 4.2.

4.3 In-Delta Storage Studies

The In-Delta storage reservoirs, because of its strategic location and proximity to the CVP and SWP diversion facilities, have a very fast response to meet the supply reliability, environmental needs and Delta water quality standards. Water stored at the In-Delta reservoirs can be released to meet the Delta salinity standards, supply needs at CVP and SWP facilities, and EWA requirements. The planned scenarios are intended to assess the benefits of the In-Delta storage reservoirs related to the following.

- CVP/SWP coordinated operations

- Water quality, particularly DOC
- Fish and aquatic habitat
- Environmental Water Account
- Climate change
- Coordinated operations with Los Vaqueros Reservoir.

CVPIA requirements are assumed to be met through the condition that no diversions are to be made during April and May. A summary of 73 year operation studies results is given in Table 4.2 and information on diversions and discharges from the In-Delta Storage islands is given in Table 4.5.

4.3.1 Study 2: CVP/SWP and In-Delta Storage Project Coordinated Operations

Study 2 is designed to reflect the coordinated CVP and SWP withdrawal assumptions as summarized in Table 4.1. This study would simulate the In-Delta operations in coordination with SWP and CVP operations including Joint Points of Diversion for the period of WY 1922 – WY1994. Some of the main constraints on the study are as follows.

- Operate island reservoirs to divert surplus Delta outflow as defined under D1641.
- No diversions will be allowed in April and May. This operation also covers CVPIA b(2) Vernalis Adaptive Management Plan actions.
- Benefit of island water discharge will be given to SWP or CVP for which change in delivery target is maximized. Decision is made each year from March to June during allocation process. In January and February, export is for SWP as CVP water allocation does not start until March.
- Water to meet the SWP and CVP Delta obligations is provided by In-Delta and exports to projects are based on COA.
- Salinity improvements benefits are realized through In-Delta Storage releases.
- Evaporation from storage can be topped off using prior water rights.
- This study provides a gross benefit of the storage project. Results in comparison to the No Action 73-year Base Study are presented in Table 4.1.

Comparison of the results between study 1 and study 2 would provide gross benefits of the project as a result of the coordinated operations of CVP and SWP. Because of the proximity of the planned reservoirs to the export locations, the coordinated operations will allow the fine tuning of the CVP/SWP operations. Since the demand (supply, environmental, and water quality) is met from the In-Delta storage, water stored at the upstream reservoirs can be used for other seasons or to meet other objectives. Thus, addition of In-Delta storage would increase the total yield of the CVP/SWP system.

Table 4.1: CVP/SWP Coordinated Operation Criteria

COA	1986 Agreement between DWR and USBR Storage withdrawals for in-basin use are shared 75% CVP and 25% SWP Unstored flows for storage and export are shared 55% CVP and 45% SWP
SWP Wheeling	CVP payback wheeling (195 taf) in Jul and Aug Up to 128 taf/year for Cross Valley Canal Wheeling for Cross Valley Canal is modeled by wheeling CVP water to CVP San Luis

4.3.2 Operations for Water Quality

The In-Delta storage reservoirs when added to the CVP/SWP systems will have impacts on the water quality of Delta area and thus the reservoirs will be operated under D1643 constraints. As constraints dictated by D1643 are to be applied, initial water quality conditions should be known. For this purpose, CALSIM is used in conjunction with DSM2 to compute the baseline water quality constituents. Firstly and because of the underlying peat soil, it is recognized that DOC is the major issue to be resolved. Secondly, the amount of water needed to meet all other water quality constraints is to be computed.

The period selected for water quality studies from October 1975 to September 1991 is based on the water quality data being used in the DSM2 Model. This period represents the below average flow conditions in comparison to the 73-year 1921 to 1994 historical time period used for other studies. Thus reservoir yields in water quality indicate lower numbers than the 73-year period.

Two types of modeling studies are done to identify the DOC issue:

- setting up the initial DOC baseline conditions for project runs for D1643 constraints without DOC (73-year Study 3 and 16-year Study 3a); and
- D1643 constraints with DOC to determine the magnitude of impact on SWP and CVP project operations (Study3b).

Then, water circulation needs are determined so that the island reservoirs can be operated within the required DOC standards (Study 4). Water quality assessments are also done with the water quality D1643 and WQMP constraints to evaluate the improvements to the Delta water quality with In-Delta reservoir filling and release operations on a long-term basis (Study 5).

4.3.2.1 Study 3: Initial Pre-Project and Project DOC Conditions

To establish the initial conditions for DOC, CALSIM study was conducted for the period of WY1974 through WY1991. The study considered provisions from D1641 and D1643, however, without the DOC constraints. The results were passed to DSM2 model to determine the pre-project water quality conditions of the Delta. The following steps in running CALSIM and DSM2 studies show the reiterations between the two models. Also, it shows how interface with Particle Tracking model and DYRESM model (Flow Science Inc.) is provided.

- CALSIM (Study 1) D1641 No Action Base Case 8500 SWP/CVP/Joint Points of Diversion/Rev Fish without DOC.
    - ***Develop DSM2 (Scenario1)No Action Base Case***

- CALSIM (Study 3) D1643 Project without DOC Constraints**.**
    - ***Develop DOC dispersion rules using DSM2 (Scenario 2) and Particle Tracking Model***
    - .
- CALSIM (Studies 3a for lower OC rate and Study 3b for higher OC rate) D1643 Project with DOC.
    - ***Identify DSM2 (Scenario 3) Project DOC violations in comparison with No Action Base Case***
    - .
- CALSIM (Study 4) Circulation D1643 Project with DOC. Apply dispersion rules and circulation. Bring DOC close to DSM2 Base case.
    - ***Check with DSM2 (Scenario 4) for WQ compliance and improvements.***

- CALSIM (Study 4) and DSM2 (Scenario 4) Check reservoir stratification with DYRESM

DOC of the water channel sources (Sacramento River and San Joaquin River) coming into the reservoir is known from historical field measurements. When water is stored over peat soils, DOC growth occurs as indicated by field investigations and laboratory experiments. DOC Growth Logic was developed which shows DOC Growth correlation with time of storage. This logic has been incorporated within the CALSIM and DSM2 models. Also, Particle Tracking Model run was made to determine how much flow from each island will be going to the urban intakes and what will be the DOC dispersion for these intakes. Water quality dispersion rules have been developed from this study.

Also, by running a study with DOC constraints will indicate how much project yield is impacted if DOC constraints are imposed. Two growth rates for organic carbon: 0.47g C/m^2/day and 0.24g C/m^2/day were used for DOC change in the reservoir islands.

Initial DOC conditions and quantity of water which cannot be released due to DOC constraints without circulation or re-operations are given in Table 4.3.

4.3.2.2 Study 4: DOC Resolution Through Circulation

Two additional scenarios were designed to assess the role of circulation in the total yield of In-Delta storage reservoirs. As in study 3, the In-Delta reservoirs will be operated based upon the D1641 and D1643 constraints. However, an amount of up to 1,000 cfs will be circulated between the reservoirs and the channels, whenever favorable conditions exist between reservoir and slough. Specially, the amount of circulation is controlled by the fact that any release from the reservoirs should not cause increase in the DOC value at the urban intakes of more than 1 mg/L.

Constant circulation of the water between island and the slough will help in lowering the DOC concentrations in the reservoir islands. Two ways of circulation on each island are used.

- Gravity Flow Circulation: As the new water with lower DOC is passed through reservoir, DOC concentration will go down. For gravity circulation maximum use of the high and low tide variations is made and gates are opened to circulate water through reservoirs.

- Combined Gravity and Pumping Circulation: As a second circulation option, pump operations are used when the channel DOC is at least 10 mg/L lower than the reservoir DOC. Additional pumping will be justified through increase in yield.

Circulation studies were also done for two growth rates: 0.47mgs/m^2/day and 0.24mgs/m^2/day. Results of the circulation studies are shown in Table 4.3.

4.3.2.3 Study 5: Water Quality Improvements

With changes in flow conditions in the Delta with the In-Delta Storage Project may cause changes in the water quality of channels and the urban intakes. Evaluations under this study were done to assess any improvements in water quality constituents due to reservoir operations. These improvements may be related to:

- Salinity expressed in terms of EC or chlorides or X2 position as with management of Delta flows through In-Delta operations, X2 could be pushed downstream that can result as a benefit to the fisheries as well as water supply; and

- An increase in organic carbon in channels adjacent to reservoirs may benefit fisheries.

Results of Study 5 with D1643 rules for water quality were compared to Study 1, the No Action baseline conditions. These results are presented in Table 4.2.

4.4 Fish and Aquatic Habitat Evaluations

Two studies were designed with D1643 constraints to either maintain or improve the delta fishery and aquatic resources. The potential seasonal operational patterns of the island reservoirs were developed to address the restoration of habitat or mitigation for impacts of Delta diversions on the sensitive fish species. The reservoir operations should be done in such a way that the quality and availability of aquatic habitat within the Bay-Delta system and tributaries is improved. The evaluations would be done in two ways; using current operating procedures with or without D1643 and biological opinion constraints or enhancements, and secondly performing a drought reliability scenario not including the Environmental Water Account actions.

4.4.1 Study 6: Long Term Fish and Aquatic Habitat Protections

The 1997 Final Operations Criteria of the USFWS has constraints related to the Fisheries Mid-term Water Trawl Index (FMWT) of less than or higher than 239. This index is developed for each year based on delta smelt abundance during the months from September to December. FMWT Index data is available from 1967 to 1994. Data indicates there are 8 years during this period when the FMWT index is lower than 239. These restrictions apply if the index shows a significant decline in delta smelt abundance. The first evaluation was done with FMWT higher than 239.

Study 6 covers the WY1922 to WY1994. In this study results from Study 3, which has constraints dictated by D1643 including fisheries and water quality actions, will be compared with a scenario (Study1) that does not include fisheries and habitat related actions. The difference between the two alternative operations will give the water needed to take all the fisheries and habitat actions. Results of this study are presented in Table 4.2.

4.4.2 Study 7: Fisheries and Habitat Protections During Drought and Extreme Conditions

During the drought and extreme dry conditions, optimized operations are required to meet requirements of competing water uses. This scenario was designed such that no supplemental water is available through EWA operations.

Thus the study depicts a drought condition. According to the imposed constraints, no diversions will be made from February 15 to the end of June if FMWT is less than 239. FMWT Index data are available from 1967 to 1994. Data indicates there are 8 years during this period when the FMWT index is lower than 239. The criteria provide for a higher partial value of FMWT if it is available before its final calculation in December.

If the index shows a significant decline in delta smelt abundance (FMWT <239) and there are drought-related or extreme dry conditions, In-Delta reservoirs operations should be coordinated with the upstream SWP and CVP reservoirs. In-Delta storage operations result in additional water in upstream reservoirs as carryover storage. Further coordination between the fisheries regulatory agencies and operators is required to make supplies available for fisheries and habitat restoration during such extreme periods.

To determine the water needs to meet requirements for FMWT Index less than 239, results from two CALSIM II runs were used. Results of model study for a period from 1967 to 1994 for which FMWT Index was less than 239 in 8 years of to 28 years, were extended with the assumption that 28 Percent of the time these types of extreme conditions will occur over the 73-year period. Weighted project yield using Study 6 resulted in a water requirement of 14 taf $(90 \times 0.72 + 41 \times 0.28) = 14$. With In-Delta operations, on average annual basis additional supplies of 14 taf (Table 4.2) are required for the historical 73-year period.

4.5 Study 8: Environmental Water Account

Water can be stored in the In-Delta reservoirs as part of the EWA. In-Delta storage can be used to make up for the reduction in SWP and CVP exports during sensitive fish periods. Under D1643 criteria, reduction in annual yield due to fisheries actions is 56 TAF in Study 6 and 70 TAF in Study 7 under extreme conditions. This was assumed as the EWA requirement for the In-Delta Storage Project.

Under this scenario, a firm EWA supply of 900 cfs was allocated for EWA purposes. This amount was based on the assumption that in the base case No Action scenario for Revised Fish, 50 percent of the expanded Banks capacity from 6680 cfs to 8500 cfs will be used for EWA. This is possible either through direct connection to Clifton Court Forebay or dedicating In-Delta releases up to 900 cfs for this purpose. The advantage of direct connection is the elimination of fish screening at the Clifton Court Forebay. This will benefit fisheries as fish mortality will be reduced as a result of reduced fish intake. Also, SWP and CVP will benefit as there would not be any pump stoppages at Clifton Court due to presence of sensitive fish species.

EWA allocation of 900 cfs was made for the modeling run to calculate environmental benefits for the 73-year period. EWA and diversion amounts was not included in the inflow export ratio. A comparison of results with No Action baseline Study 1 is shown in Table 4.2.

4.6 Study 9: Climate Change Impact

This scenario would be designed to assess the impacts of climate change on the In-Delta storage project yield. In this study the projects will be operated based upon the D1641 constraints. The hydrology is modified to reflect the changes in the climate in the region. Results are compared with No Action Baseline Study 1. The objective of the scenario is to evaluate the overall performance of the project under changed climate scenario. Because of the location of the project, In-Delta Storage would capture early spring flows and store additional water that may end up in the Bay. Results of this scenario are shown in Table 4.4. Average annual increase in SWP from such operations is 156 taf in comparison to 146 taf for Study 2 without climate change. The results indicate that the project yield will increase over time due to the capture of additional runoff.

4.7 Study 10: Coordinated Operations with Other Storage Projects

Purpose of this study was to assess if there are additional benefits of considering In-Delta operations in coordination with other storage projects (Shasta Enlargement, Sites Reservoir and Los Vaqueros expansion). In addition, it was also the intent to see if these projects are competing for the same surplus water. These projects are at different level of development study. Some of the studies are very preliminary and no final operational plans have been developed. Focus of this study was on trend evaluation rather than importance of numbers. The current operational studies for Operation other storage projects are appraisal level scenarios based on D1641 requirements with 2020 hydrology based on a monthly time step, whereas In-Delta has additional D1643 constraints and CALSIM II modeling application is on daily basis.

Diversion information for the Los Vaqueros expanded reservoir was obtained from the ongoing planning studies. Los Vaqueros diversions assume a secondary use of the project after leaving a surplus flow buffer of 5,000 to 10,000 cfs that can be used by expanded Banks 8,500 cfs and future extensions in the SWP and CVP system like In-Delta storage. Daily CALSIM II operations for In-Delta Storage Project were run assuming Los Vaqueros planning study diversions. Results of this scenario are presented in Table 3.1 (Study 10). The study results indicate that these two projects can be operated in coordination and project operations can be maximized for additional benefits..

Table 4.2: Summary of Operation Study Results

CALSIM-II Study No. Study Period Oct 1922-Sept 1994	Delta Needs WQ/Fish/D1641		Total SWP/CVP Delivery (TAF)	Change in SWP/CVP Delivery (TAF)	Total Carryover Storage (TAF)				Trinity River Channel Flow (TAF)
	D1641	Fish			Oroville	Shasta	Folsom	San Luis	
Study 1: No Action Base Case (D 1641)	-	-	5772	-	2025	2400	482	454	733
Study 2: SWP/CVP and In-Delta Coordinated Operations (D1641)	38	-	5918	146	2088	2411	485	475	739
Study 5: Water Quality Improvements (D1641 and D1643)	25	56	5862	90	2076	2405	485	473	739
Study 6: Long Term Fish and Aquatic Habitat Protections (D1641 and D1643)	25	56	5862	90	2076	2405	485	473	739
Study 7: Fish and Aquatic Habitat Protections during Drought and Extreme Conditions (FMWT<239 with D1641 and D1643)	11	70	5848	76	2050	2404	485	471	739
Study 8: Environmental water Account (EWA with D1641 and D1643)	13	29	5889	117 (EWA=56)	2074	2413	482	465	743
Study 10: Coordination with Los Vaqueros Expanded Reservoir (D1641)	37	-	5910	138	2088	2405	481	479	736

Table 4.3: Summary of CALSIM II Organic Carbon Study Results

CALSIM-II Study No. Period Oct 1975-Sept 1991	DOC Growth Rate (g C/m^2/day)	Total SWP/CVP Delivery (TAF)	Change in SWP/CVP Delivery (TAF)	Total Carryover Storage (TAF)				Trinity River Channel Flow (TAF)
				Oroville	Shasta	Folsom	San Luis	
Study 1: No Action Base Case (D1641)	-	5453	-	1936	2344	450	476	764
Study 2: SWP/CVP and In-Delta Coordinated Operations (D1641)	-	5522	69	1963	2381	451	525	766
Study 3: Initial Project Conditions without DOC (D1641&D1643)	-	5526	73	1988	2353	450	494	765
Study 3a: Initial Project with DOC (D1641&D1643)	0.24	5530	77	1902	2349	450	480	765
Study 3b: Initial Project with DOC (D1641&D1643)	0.47	5534	81	1877	2348	451	482	765
Study 4a: DOC Resolution through Circulation (D1641 and D1643 with DOC)	0.24	5519	66	1936	2349	451	481	765
Study 4b: DOC Resolution through Circulation (D1641 and D1643 with DOC)	0.47	5518	65	1915	2345	450	481	763

Table 4.4: Summary of Climate Change Study Results

CALSIM-II Study No. Study Period Oct 1922-Sept 1994	Total SWP/CVP Delivery (TAF)	Change in SWP/CVP Delivery (TAF)	Total Carryover Storage (TAF)				Trinity River Channel Flow (TAF)
			Oroville	Shasta	Folsom	San Luis	
Study 1_CC*: No Action Base Case (D 1641)	5740	-	1794	2232	462	429	701
Study 9: Climate Change Impacts (D1641)	5896	156	1861	2254	461	442	703

*Study 1_CC – Modified hydrology for climate change

Table 4.5: Summary of Average Annual Discharges and Diversions for In-Delta Storage Reservoirs

CALSIM-II Study No. Study Period Oct 1922-Sept 1994	Discharge from In-Delta Storage Project (TAF)			Diversion to In-Delta Storage Project (TAF)		
	Discharge from Webb Tract	Discharge from Bacon Island	Total Discharge	Diversion to Webb Tract	Diversion to Bacon Island	Total Diversion
Study 2: SWP/CVP and In-Delta Coordinated Operations (D1641)	122	154	276	130	163	293
Study 5: Water Quality Improvements (D1641 and D1643	67	103	170	74	112	186
Study 6: Long Term Fish and Aquatic Habitat Protections (D1641 and D1643)	67	103	170	74	112	186
Study 7: Fish and Aquatic Habitat Protections during Drought and Extreme Conditions (FMWT<239 with D1641 and D1643)	35	52	87	41	59	100
Study 8: Environmental water Account (EWA with D1641 and D1643)	58	99	157	65	106	171
Study 9: Climate Change Impacts (D1641)	118	149	267	127	159	286
Study 10: Coordination with Los Vaqueros Expanded Reservoir (D1641)	123	152	275	132	162	294

Chapter 5: Benefit Evaluations

5.1 General

The operation studies conducted using the CALSIM and DSM2 models provide technical basis for the analyses of the project yields. The yield assessments are made for various operational scenarios of the planned project relative to existing baseline conditions. The operation analyses cover the impacts of the In-Delta storage project in the CVP/SWP coordinated operations, water quality (particularly DOC), fish and aquatic habitat, environmental water account, and coordinated operations with Sites and Los Vaqueros Reservoirs. The operational study also assesses the yield of the project under climate change scenarios and drought conditions.

5.2 Project Benefits

5.2.1 SWP and CVP System Operational Flexibility and Water Supply Reliability

Regional and system-wide benefits are related to increase in exports, contribution of In-Delta Storage to Delta requirements and increase in carryover storage in San Luis and upper SWP and CVP reservoirs. As shown in Figure 5.1, the system reliability probability analysis indicates increased reliability at all times.

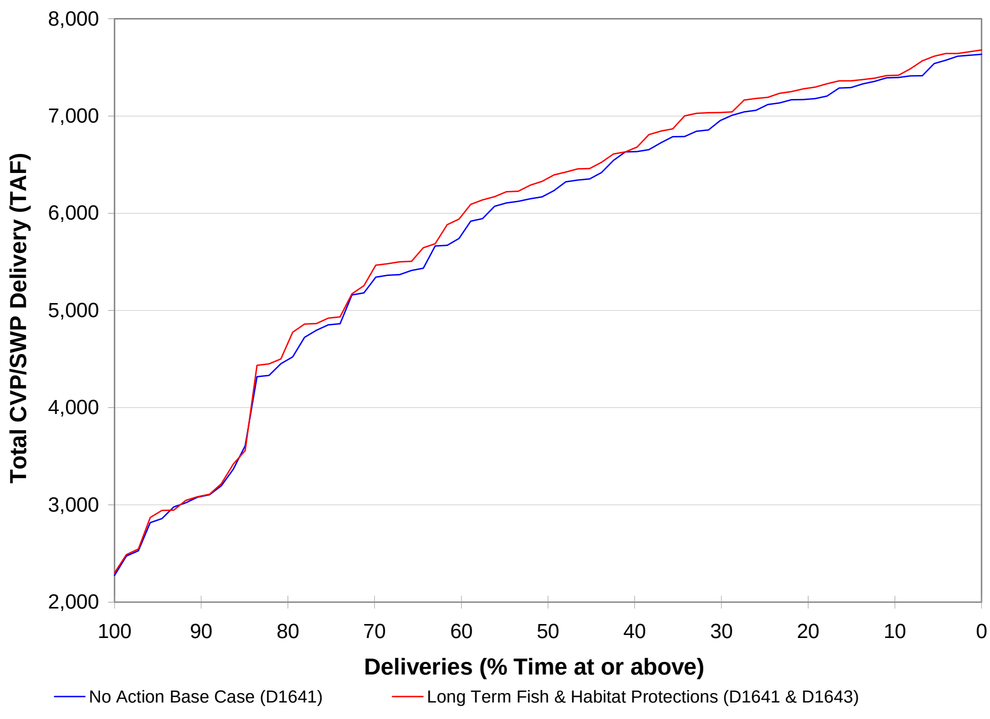


Figure 5.1: Water Supply Reliability

The system-wide impacts extend not only to South of the Delta but are also realized in the North. Increase in CVPIA refuge water in addition to the agricultural and urban supplies results from the capturing of surplus water by additional storage in the system. Also, as SWP and CVP obligations are met by new storage, carryover storage becomes available for system reliability and flexibility uses. Benefits occur as far as the Trinity River system as Shasta requirements are reduced for diversions from Trinity. Additional reduction in Trinity water diversions (Table 4.2) to Shasta can be used for Trinity River environmental purposes.

The measure of flexibility could not be translated to monetary value. However, it is obvious that in-Delta storage adds considerable operational flexibility for aquatic resources, water quality, Delta requirements and water supply operations.

Typical reservoir operations for a below normal year like 1979 that followed the historically severe drought of 1976-77, are shown for Webb Tract in Figure 5.2 and for Bacon Island in Figure 5.3.

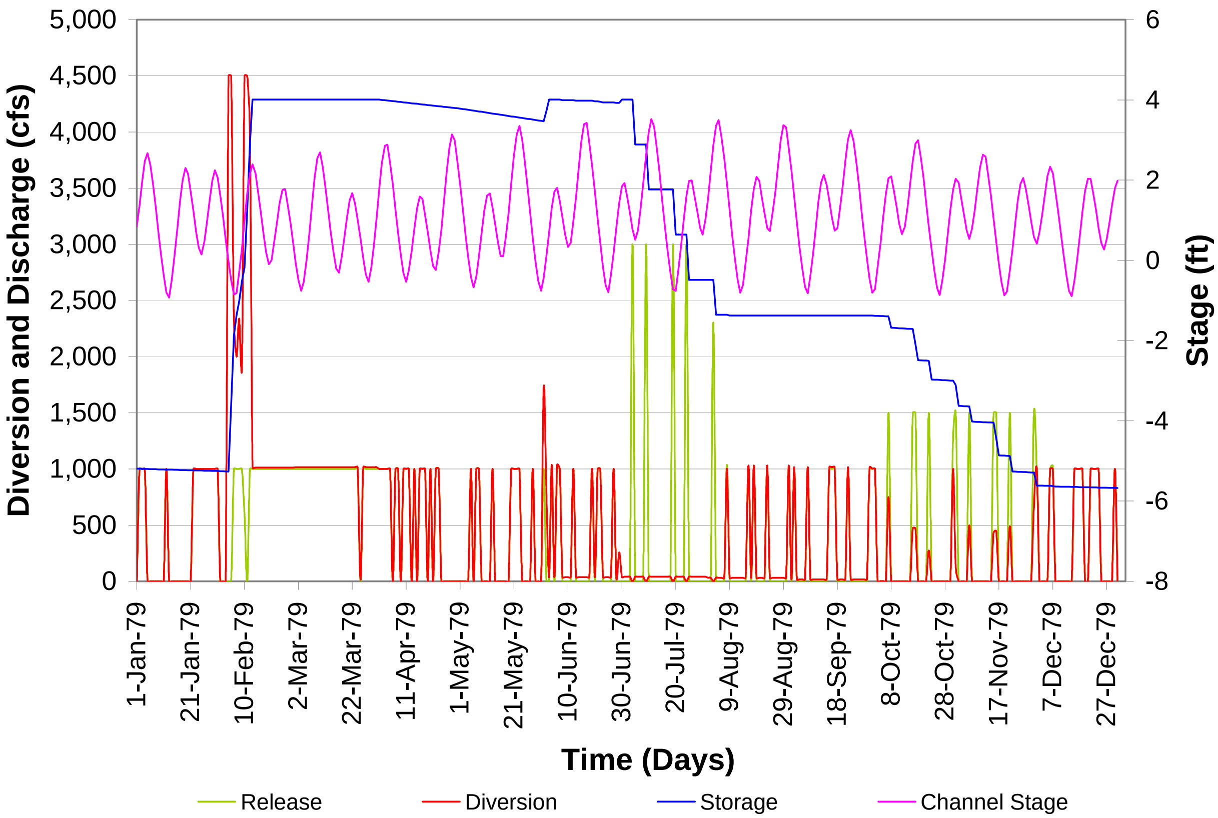


Figure 5.2: Webb Tract Operations in Below Normal Year (1979)

Plotting channel tidal levels and reservoir stage together shows when water can be diverted by gravity, gravity and pumping, and pumping only operations. Organic carbon operations for a typical below normal year at Banks and Tracy are shown in Figures 5.6 and 5.7, respectively. This operation also includes fisheries actions. It is possible to fill the reservoir by February and results support the fact that lower level storage can be managed to keep water in the reservoir so that dry reservoir conditions do not occur during the year.

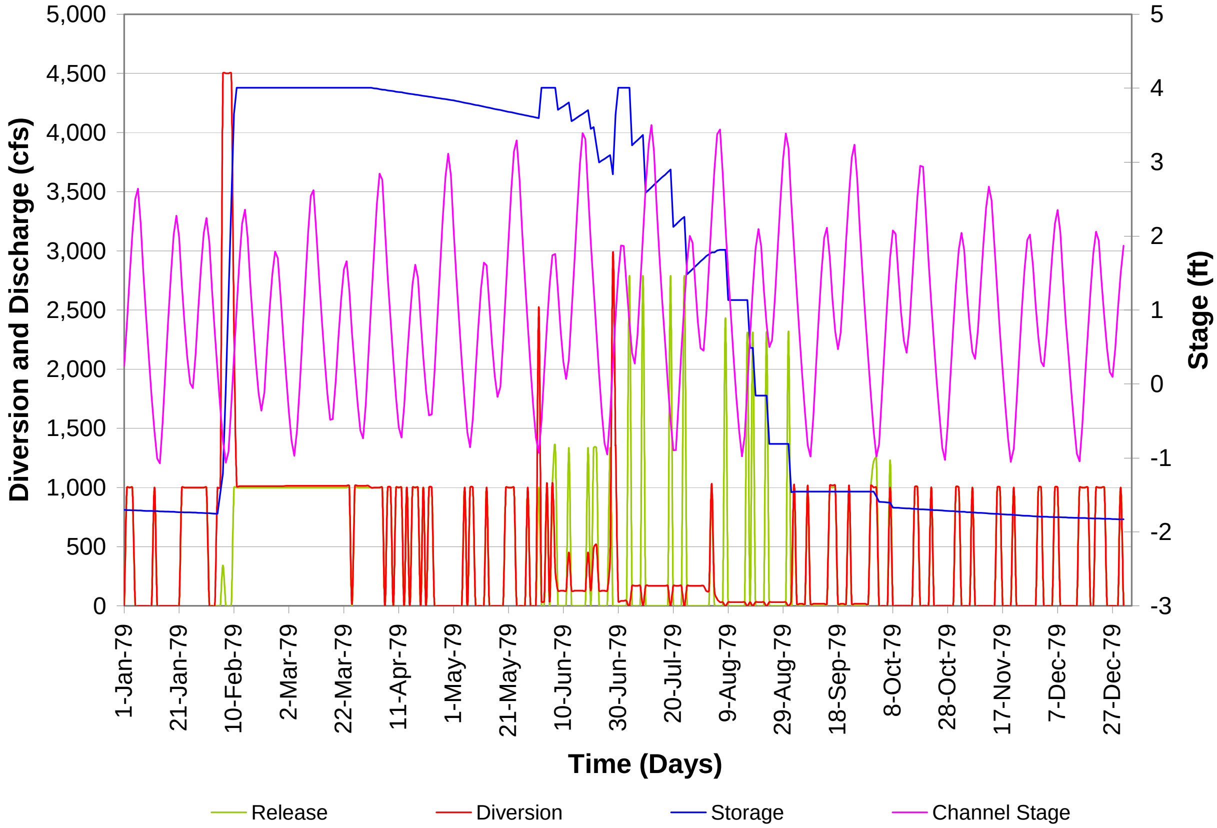


Figure 5.3: Bacon Island Operations in Below Normal Year (1979)

5.2.2 Carryover Storage Benefits

Additional carryover storage is available in upstream reservoirs as shown in Figure 5.4.

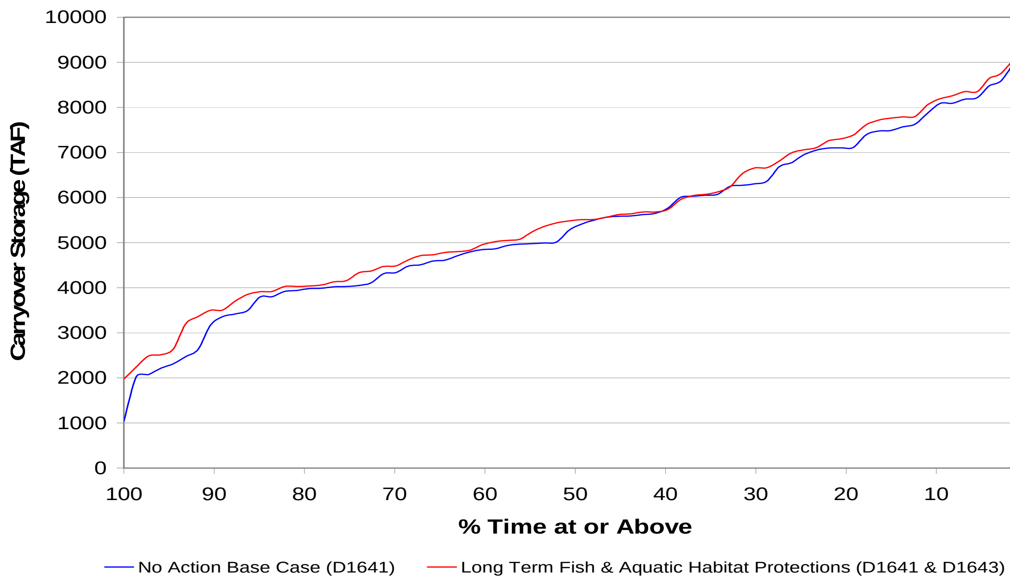


Figure 5.4: Long-term System Carryover Storage

Uses of this storage can be optimized through further operational studies in coordination with upstream reservoirs. Operations can be refined by:

- flow augmentation in the Sacramento River;
- moving water during fall months to In-Delta storage for Delta ecosystem and EWA use; and
- using water for temperature control and other water quality benefits.

5.2.3 Water Quality Improvements

5.2.3.1 Salinity/X2 Improvements

Storage operations were run with water quality constraints that indicate there could be improvements to the water quality in the Delta. The location of the 2 ppt salinity isohaline (X2 location) has been identified as an important indicator of estuarine habitat conditions within the Bay-Delta system. The location of X2 within Suisun Bay during the February to June period is thought to be directly and/or indirectly related to the reproductive success and survival of the early life stages for a number of estuarine species. Abundance of several estuarine species is greater when the X2 location during the spring occurs within the western portion of Suisun Bay with lower abundance correlated with those years when the X2 location is further to the east.

As shown in Figure 5.5, long-term improvements are visible during the February to June months, as well as during earlier months, and this could be useful to fisheries survival. In addition, salinity treatment costs for drinking water may be reduced with these operations.

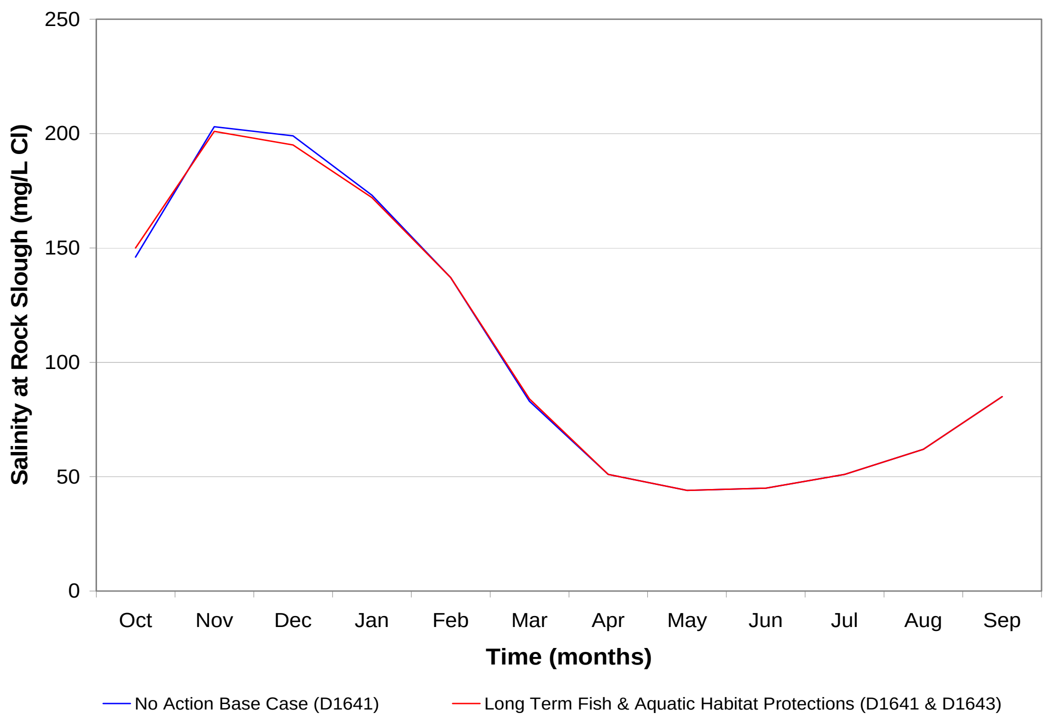


Figure 5.5: Long-term Average Annual Salinity Improvements

5.2.3.2 Organic Carbon Evaluations

A typical worst case situation during a below normal year like 1979 is shown in Figure 5.6 for Banks and Figure 5.7 for Tracy. In early winter when the reservoirs fill up in February, organic carbon levels stay within the 1 mg/L standard of the No Action baseline conditions. A review of results given in Table 4.3 shows that application of D1643 results in lower carryover storage in upstream reservoirs even if the yield is higher than the base conditions. In actual In-Delta storage operations with D1643, during the following months, DOC concentrations are controlled through circulation and lowering of upstream reservoirs is avoided. The final yield value is closer to the D1641 operations yield during the 1975 to 1991 period.

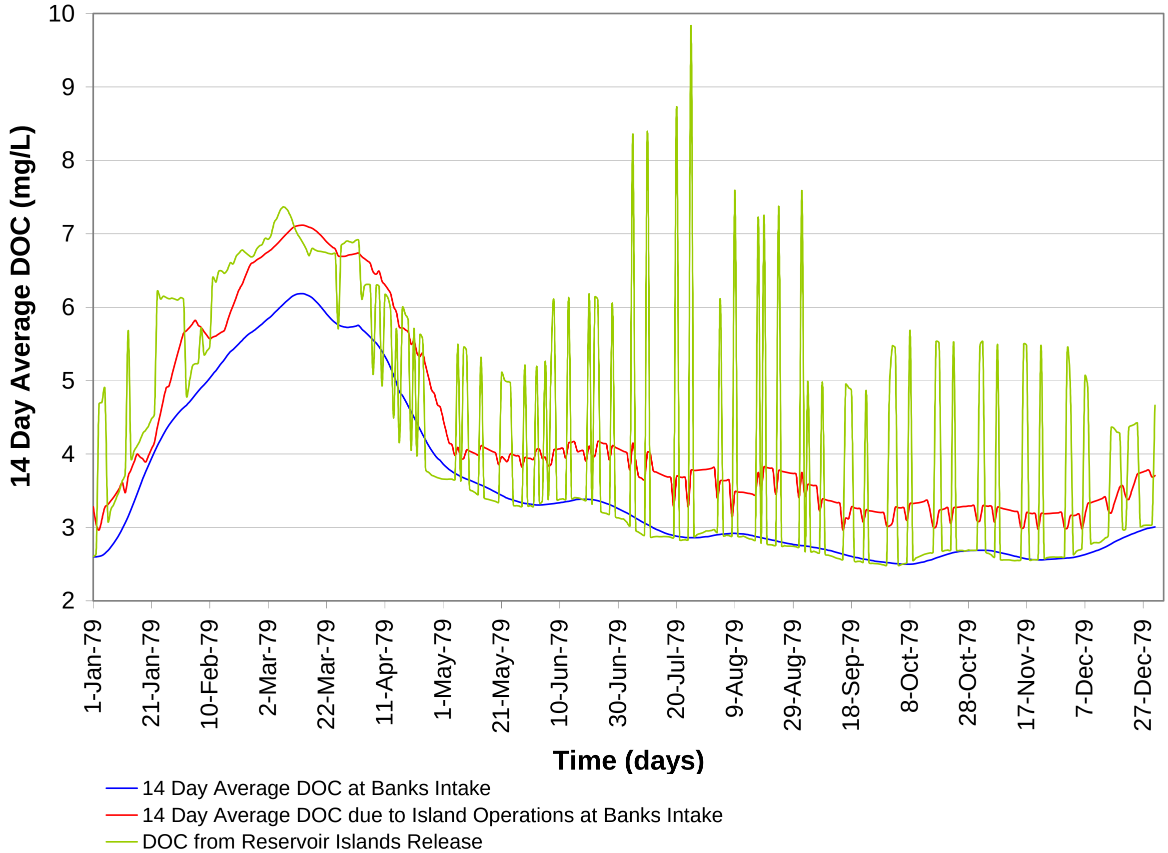


Figure 5.6: Organic Carbon Operations at Banks for Typical Below Normal Year

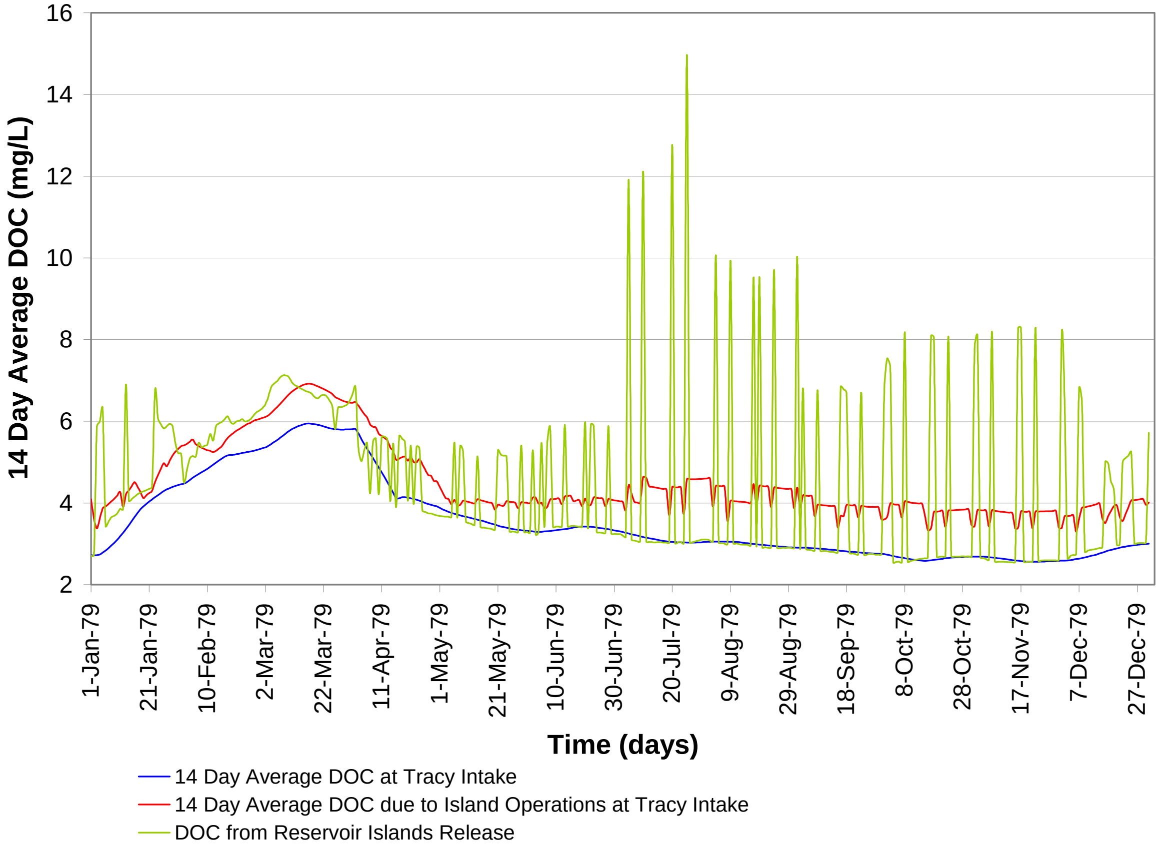


Figure 5.7: Organic Carbon Operations at Tracy for Typical Below Normal Year

5.2.4 Fish and Aquatic Habitat Benefits

The location within the Delta of the In-Delta Storage project is unique and allows swift action to be taken to respond to instream flow requirements for fish and aquatic habitat. Seasonal timing and magnitude of water diversions from the Delta may affect aquatic species directly through entrainment and impingement or indirectly through changes in hydrologic conditions and aquatic habitat.

Results of operational studies indicate water stored during wet years in the Delta and additional carryover as a result of new storage can be used for fish and aquatic habitat improvements. There would be an increase in channel organic carbon close to the reservoir outlets that could benefit channel fisheries habitat. These ecological benefits could need evaluation.

Environmental water allocations during February through June and the resulting decreases in SWP exports would reduce the frequency and magnitude of reverse flows in the lower San Joaquin River. This would also contribute to the X2 position being located more within the western Delta, and increase Delta outflow. As a result the quality and availability of aquatic habitat for fish would be improved. Additional water stored in the In-Delta storage reservoir islands could be used to meet the ERP requirements.

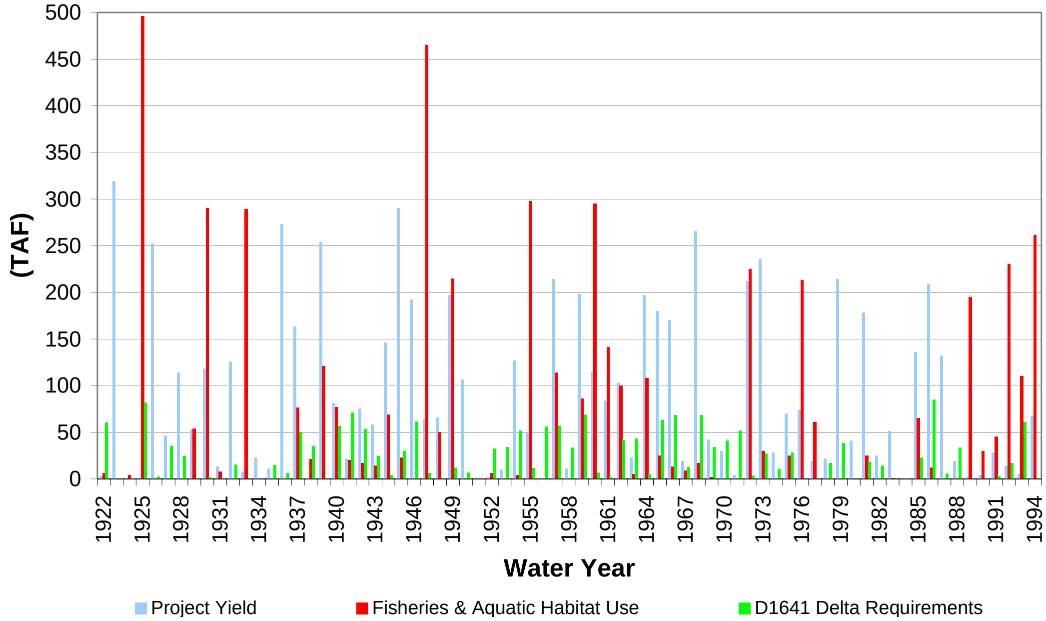


Figure 5.8: Delta Requirements and Fish and Aquatic Habitat Benefits

5.2.5 Environmental Water Account

EWA diversions can be used to counteract reductions in SWP and CVP exports with a resulting reduction in fish salvage at the SWP export facilities and improvements in X2, QWEST, and Delta outflow from February through May. Figure 5.8 shows probability analysis results (in terms of percentage of the time at or above the plotted values) of how much water a dedicated 900 cfs capacity for EWA will provide from the In-Delta Storage project.

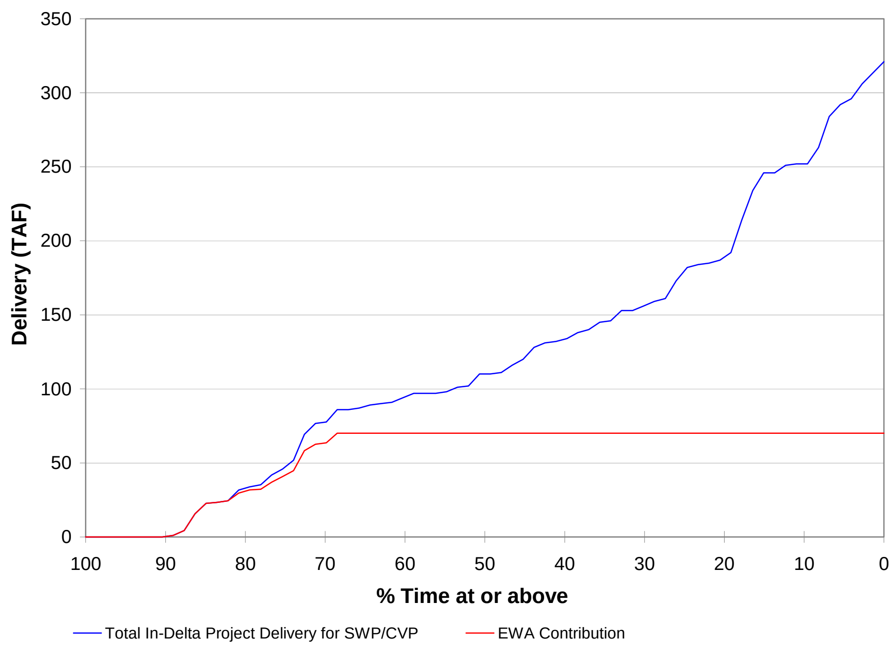


Figure 5.9: Dedicated In-Delta Storage Supply Contribution to EWA

5.3 Conclusions and Recommendations

A number of operation scenarios were analyzed using the CALSIM and DSM2 models to evaluate the impacts of In-Delta storage reservoirs in terms of environmental enhancements of the Delta, supply reliability and water quality improvements, and operations of CVP and SWP systems. The studies covered a wide range of operation scenarios for the 2020 level of hydrology, level of development, and demands. Based on the modeling studies results, the following conclusions have been made for the In-Delta Storage Project.

- Presence of In-Delta storage reservoirs creates carryover storage in upstream CVP and SWP reservoirs.
- EWA benefits could be provided either by dedication of 900 cfs supply to CVP and SWP or by a direct connection to Clifton Court Forebay.
- Coordinated Operation of CVP and SWP would help meet the ecosystem needs of the Delta.
- Due to strategic location of the In-Delta reservoirs, immediate actions are possible for salinity control. The reservoirs have a favorable impact in the location of X2 line in the Delta.
- DOC water quality problem could be mitigated using circulation operations.

Due to strategic location, the operation of the island reservoirs would contribute to operational flexibility of the SWP and CVP systems. Resolution of water quality issues is possible with circulation of water through island reservoirs. Future operations can be refined in consultations with regulatory agencies for improvements in habitat quality and availability for fish and other aquatic organisms inhabiting the Bay-Delta system. The timing of environmental water allocations would be flexible depending on the specific environmental benefit to be achieved (e.g. protection of spring-run chinook salmon and delta smelt). Due to the possibility of large carryover storage in the upstream SWP and CVP reservoirs as a result of storing water in the Delta, CALFED's ERP and storage programs should work closely with regulatory agencies to maximize the program benefits and assure compliance of the Endangered Species Act.

EWA studies for the In-Delta Storage Project support large EWA benefits for two options: a dedicated release from Bacon Island to counteract the SWP and CVP pumping curtailments without direct connection to Clifton Court Forebay (CCF), or a firm delivery with direct connection to CCF. A direct connection to CCF using a pipeline would provide "fish free" water, because the water was screened using state-of-the-art fish screens on Bacon Island would support the Conveyance Program's goal to screen CCF up to 10,300 cfs. Further evaluation of this connection as a part of the conveyance studies is recommended to evaluate possible savings in fish screening structures being proposed for the new CCF Intake.

In-Delta Storage Project and the Los Vaqueros Expansion Project were modeled, and evaluation indicates that both projects can be operated in coordination. Further evaluation of shared diversion points would result in additional benefits and cost savings. Comparative information on the other three CALFED storage programs (Shasta Enlargement, Sites Reservoir and Storage in the San Joaquin Basin), could not be completed within the time limits of this study. Comparative information on four storage programs (Shasta Enlargement, Sites Reservoir, Los

Vaqueros Expansion and Storage in the San Joaquin Basin), based on daily modeling is required for evaluation of benefits of joint operations. As these projects are at different levels of study, evaluations should be made based on common assumptions and overall benefit choices are to be defined.

Appendix A - SWRCB Decision 1643

A.1 Diversion Criteria

- Diversion to storage could only occur when Delta is in excess conditions and surplus flows are available.

- Initial diversions to DW Project shall not be made for the current water year (commencing October 1) until X2 has been west of Chipps Island (75 km upstream of the Golden Gate Bridge) for a period of ten (10) consecutive days. After initial X2 condition is met, diversions shall be limited to a combined maximum rate of 5,500 cfs for five (5) consecutive days.

- Maximum rate of diversion onto either Webb Tract or Bacon Island would be 4,500 cfs (9taf/day). The combined maximum daily average rate of diversion for all islands (including diversions to habitat islands) will not exceed 9,000 cfs.

- The maximum annual amount diverted to Webb Tract storage shall not exceed 155 taf per year from January 1 to March 31 and June 1 to December 31 and shall not exceed 106,900 af per year from December 15 to March 31. The total amount of water taken from all sources shall not exceed 417 taf per water year of October 1 to September 30.

- The maximum annual amount diverted to Bacon Island storage shall not exceed 147 taf per year from January 1 to March 31 and June 1 to December 31 and shall not exceed 110,570 AF from December 15 to March 31. The total amount of water taken from all sources shall not exceed 405 taf per water year of October 1 to September 30.

- Diversions shall not exceed 1000 cfs when the 14-day running average of X2 is farther than 80 km upstream of the Golden Gate Bridge, nor exceed 500 cfs if the 14-day running average of X2 is farther than 81 km upstream of the Golden Gate Bridge.

- No Diversions to storage will be made if the Delta is in excess conditions and such diversions cause the location of the 14-day running average of X2 to shift upstream (east) such that X2 is:
  - East of Chipps Island (75 river kilometers upstream of the Golden Gate Bridge) during the months of February through May, or
  - East of Collinsville (81 kilometers upstream of the Golden Gate Bridge) during the months of January, June, July, and August, or
  - During December, east of Collinsville and delta smelt are present at Contra Costa Water District's point of diversion under Water Right Permits 20749 and 20750.

- In the period from September through March DW shall not divert water to storage when X2 is located upstream of Collinsville salinity gauge.

- In the period from October through March, DW Project shall not divert water to storage if the effect of DW Project diversions would cause an upstream shift in the X2 position in excess of 2.5 km (i.e., increase the X2 by 2.5 km).

- In the period from April through May, DW Project shall not divert water to storage.

- If the delta smelt FMWT index is less than 239 (FMWT<239), DW shall not divert water for storage from February 15 through June 30.

- DW Project diversions to storage shall not exceed the following percentage of the available surplus water if FMWT Index > 239:

Month	OCT- JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG- SEP
Diversion (%)	90	75	50	0	0	50	75	90

- If FMWT < 239, DW Project diversions to storage shall not exceed the following percentage of the available surplus water:

Month	OCT-JAN	FEB(1-14)	FEB(15-28)-JUNE	JUL	AUG-SEP
Diversion (%)	90	75	NA	75	90

- DW Project diversions to storage shall not exceed a percentage of the previous day's net Delta outflow rate (assume FMWT Index > 239 scenario):

Month	OCT-DEC	JAN-MAR	APR	MAY	JUN-SEP
Diversion (%)	25	15	0	0	25

- If FMWT<239, DW Project diversions to storage shall not exceed a percentage of the previous day's net Delta outflow rate:

Month	OCT- DEC	JAN-FEB(14)	FEB(15-28) -JUN	JUL-SEP
Diversion (%)	25	15	NA	25

- In the period from December through March, DW Project Diversions to storage shall not exceed the percentage of the previous days San Joaquin River inflow rate.

- If FMWT Index > 239, this limit applies for 15 days during the December through March period whenever DW Project diverts water to storage.

Month	DEC	JAN	FEB	MAR
Diversion (%)	125	125	125	50

- If FMWT Index < 239, this limit applies for 30 days during the December through March period whenever DW Project diverts water to storage.

Month	DEC	JAN	FEB(1-14)	FEB(15-28)	MAR

Diversion (%)	125%	100%	50%	NA	NA

- For the month of March diversion to DW Project shall be reduced to 550 cfs in unless QWEST remains positive.

- Reduce diversion rate to 50% of the previous day's diversion rate during the presence of delta smelt.

- In the period from November through January, when the Delta Cross Channel gates are closed, DW Project shall limit diversions to storage as follows:

Delta Inflow	Maximum Combined Diversion Rate
<=30,000 cfs	3,000 cfs
<=50,000 cfs & >30,000 cfs	4,000 cfs

- Water will be diverted onto Bacon Island and Webb Tract from June through October in order to offset actual reservoir losses of water stored on those islands, referred to as "topping-off" reservoirs. Topping-off diversions shall not exceed the following maximum diversion rate (cfs) and maximum monthly quantity (taf) listed below:

Month	JUN	JUL	AUG	SEP	OCT
Maximum diversion rate (cfs)	215	270	200	100	33
Maximum monthly quantity (taf)	13	16	12	6	2

The maximum topping-off diversion rates shown above shall be further limited by diversions onto the habitat islands. The maximum topping-off diversion rate and quantity shall be reduced by an amount equal to the habitat island diversions during the same period.

- From September through May, the reservoir islands may be flooded to shallow depths (1ft) to create 200 acres of shallow water rearing and spawning habitat, typically 60 days after reservoir drawdown. After shallow water flooding, water will be circulated till deep water flooding occurs in April or May.

- The maximum rate of proposed diversion onto Holland Tract and Bouldin Island will be 200 cfs per island. Diversions onto the habitat islands will not cause the combined daily average maximum diversion rate of 9,000 cfs for all four project islands to be exceeded. Water will be applied in each month of the year

A.2 Discharge Criteria

- Releases would be made at a combined maximum daily average of 9,000 cfs. Combined monthly average reservoir island discharge will be up to 4,000 cfs. Maximum annual release of stored water would be 822 taf.

- Maximum Annual export of stored water would be 250 taf.

- No discharges shall be made for export from Webb Tract from January through June.

- In the period from April through June, DW shall limit discharges for export from Bacon Island to 50% of the San Joaquin inflow measured at Vernalis.

- DW shall not discharge for export any water from the habitat islands.

- Reduce the discharge for export rate to 50% of previous day's diversion rate during the presence of delta smelt.

- DW Project discharge is subject to export limits, treated as an export in the monthly E/I ratio computation except when water is discharged for environmental water account.

- In the period from February through July, DW discharges for export shall be limited to the following percentage of the available unused export capacity at the CVP and SWP facilities:

Month	FEB	MAR	APR	MAY	JUN	JUL
Discharge (Bacon Island	75%	50%	50%	50%	50%	75%
Discharge (Webb Tract)	NA	NA	NA	NA	NA	75%

- DW shall reduce the discharge for export rate to 50% of the previous day's diversion rate during the presence of delta smelt.

A.3 Salinity Impacts

- Project Operations should not cause an increase in salinity or more than 10 mg/L chloride at one or more of the urban intakes: or

- Project Operations should not cause any salinity increase at the urban intakes in the Delta exceeding 90% of an adopted salinity standard (e.g., Rock Slough chloride standard defined in SWRCB Decision 1641Total Trihalomethanes (“TTHM”) concentrations in excess of 64 ug/L at urban intakes in the delta.